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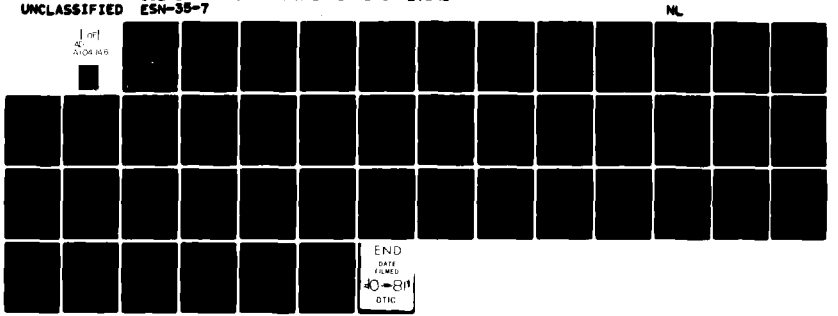

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific Literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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edited by Philip Fire, Nicholas A. Bond, Jr. and Don J. Peters

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BEHAVIORAL SCIENCES

HUMAN-COMPUTER MISMATCH

Computer specialists learn to live with the peculiarities and artificialities of systems' languages; indeed, an occupational prerequisite is a relish for the complexities of converting natural-language ideas and goals into effective program sequences. Computer people quickly learn, too, about the organizational impacts of their efforts. As computers become simultaneously cheaper and more powerful, however, there is both the potential and the need for many nonspecialist users to employ these machines advantageously. While these people may not be particularly fascinated with either the hardware or the logical elegance of the programs, they do want the computer to provide something of value to them occasionally, and they want this something without having to undergo a long apprenticeship to obtain it. Examples of these nonspecialists are easy to list: all kinds of middle managers, military officers, home users, government officials, school and social agency staff people, and health professionals.

There are plenty of obvious problems encountered by the nonspecialist person who wants to utilize the computer personally. Error messages provide a good illustration: "illegal syntax at line 0561" is not a crystal-clear guide about what the neophyte should do next, and it doesn't help to have that message repeated again and again. In timesharing systems, there are often messages, mysterious to the user, about such matters as core overload and tolerable matrix size. Most frustratingly of all, sometimes the thing just stops, doesn't do or say anything at all for a brief interval, and finally scolds the operator for trying to shut it down without following a proper "logout" sequence.

Another whole class of human-computer interaction problems stems from the way that a computer system is utilized in an organization. It usually happens that, when the initial hardware and software packages are delivered and debugged, nobody has anticipated all the major impacts that the new system will have on the people in the organization. Common sense leads to certain expectations: younger and technically-trained people will be more apt to welcome the new system than will older workers; people who are having parts of their present work "systematized" may resent the new forms and strict reporting requirements; an occasional absurd output from the system will be cited by some people as evidence for its general undesirability; and so forth. But it cannot be assumed that these expectations, however wise and valid, will cover the user-response domain. What appears to be needed is a structured approach which can encompass these organizational problems, as well as those which come from direct human-terminal transactions.

A long-term project has been initiated in the UK to attempt to provide such a structure for handling this variety of human-computer mismatch problems. Working under an IBM-UK contract, the researchers are N.V. Hammond, P.J. Barnard, and J. Morton (all of the Medical Research Council's Applied Psychology Unit, Cambridge), J.Q. Long (Ergonomics Unit, Univ. College, London), and I.A. Clark (IBM-UK).

For research into organizational aspects, the main technique used was social information generation (SIG). Essentially a group-interview method, this procedure involves assembling small groups of people who have had actual experience in a computer implementation. Eight or nine of these people are put into a room and furnished with a list of possible topics regarding the computer implementation and its impact. They start talking about their experiences, about the impact the computer system had on their jobs, and about their feelings at various times in the implementation sequence. The list which is given to them is not an agenda of items to be covered, but rather is an indication of some issues that might be discussed.

As in many group interview analyses, all discussions were taped, and participants were given identification numbers so that their contributions could be noted. To prepare the taped material for analysis, labels referring to people and specific products were removed, and a small team of people broke the comments down into statements which "had a point." Then, for each of these "good" statements, the gist and the core proposition expressed were extracted. Finally, these nuggets of meaning were organized into a hierarchical tree of attitudes. As a brief illustration, a participant might have delivered a fairly long harangue on how, following introduction of the computer, his department head came to expect more of him and also to expect an instant response from the computer system. As originally taped and transcribed, this comment

might have been full of local detail regarding the people and the situation, but the core proposition that was stated was simple enough: management expectations were excessive. Now it turns out that the effects of this expectation can be arranged hierarchically: effects on the user organization, the relations between the user's department and the computer department, and so on. The output of all the recording and the analysis is a structured, and hopefully comprehensive, set of user attitudes relating to computer system installation. The 5 top-level nodes have a time-line ordering, with "pre-planning and introduction" first, followed by "effects of the system," "use of the system," "assessment of the system," and "general attitudes." There is a maximum depth of 5 levels, with 89 nodes in all.

How would the resulting tree be useful to anybody? Well, at least in theory, the variables that emerged from the tree analysis could be expected to be present generally in computer-implementation efforts. This means that the "surface" problems obtained in the group-interview testimony, and the variables presumed to underly them, could serve a valuable alerting function. This alerting should be more effective since it is backed up by the actual concerns of experienced people. Take the matter of planning for computer use. Textbooks and managerial judgment may recommend that the implementation be "well planned." This may be good advice, but it is not very useful advice, because nobody intends to do a poor job of planning. What really may clarify the planning issue is the set of edited statements which portray the actual difficulties brought about by inadequate planning.

The hierarchical structure of attitudes and variables can be more than a mere checklist of problems. Once variables like "decision-making involvement" or "specialist responsibility" are identified, it becomes easier for managers to think of ways to score and to make accommodation for these variables. As attempts are made to meet the problems so raised, the accumulated experience should contribute to a more general understanding of what can be done. There may also be, from the SIG structure, some hypotheses about the time-related effects of computerization. At first, the organizational issues may predominate, with many people having to sort out and work through the communications and role problems; but since organizations are adaptive, these problems can usually be managed in one way or another. The technical usability problems will remain, however, and most likely will still be unsolved.

At the computer-to-individual interaction level, the UK group employed an adaptation of the verbal-protocol method. Users (presumably typical ones) were taken to a computer terminal and asked to perform operations upon a relational data base; a record was kept of their terminal commands, the results they obtained from the computer, and also of their verbal comments during the interaction. Troubling events were divided into two classes: errors, which were deducible from the terminal protocol itself, and difficulties, which were reflected in the verbal account. As might be expected, there were plenty of ordinary ergonomics problems associated with the keyboard and display system; the requirement for shifting was a frequent annoyance, to cite just one example. By far the most interesting problems, however, were those associated with the interactive language requirements for a nonspecialist user. An emerging conception is that there are "blocks of knowledge" available to the user concerning such things as the computer system itself, the data resources within it of relevance to the user, the ways of representing his/her needs to it, and so forth. In principle, the computer system might perform a quick assessment of a user's fluency in these blocks of knowledge before it starts to interact with that user. The system might then attempt a gingerly review of certain possibilities before the user actually goes to work.

One result of these methodological studies is the almost completely different material that comes from the organizational interviews and the terminal records. Yet it should be the case that problems and solutions at either level can profoundly influence events at the other level. For conducting planning and evaluative reviews of computerized systems, the methodologies and attitude structure developed from the IBM-UK work may be among the best available. (Nicholas A. Bond, Jr.)

PHYSIOLOGICAL PREDICTION OF MARGINAL BEHAVIOR?

What are the best predictors of delinquency in young adults? Sociologists often address this question in terms of class and socioeconomic opportunity variables; psychologists might look to ability, knowledge, and achievement indexes, and to the impact of nearby adult and peergroup models. Recent Scandinavian studies indicate that physiological measures may be among the best predictors available.

The May 1981 meeting at Steyning, England, on "Child Development, Public Policy, and Information" included several discussions on the value of early-years data for predicting adult adjustment, and a sample of that material is reported here. Perhaps the most convincing analyses are those which are based on a subject cohort wherein the measures are taken early in life, and the group is stable enough to be followed for some years. In the work he reported, Sarnoff A. Mednick (Univ. of Southern California and Univ. of Copenhagen) used just this type of data compilation in his longitudinal study of Danish young men. Data were taken on the usual ability and achievement variables, and there was a record of "family environment" in the home, reflecting such items as parental separation and divorce. Two kinds of physiological data, taken in pre-teen years, were also available on each subject: (1) An electroencephalogram (EEG) pattern (e.g., proportion of slow alpha waves) and (2) An autonomic nervous system (ANS) pattern (e.g., galvanic skin response recovery rate).

Some fair predictions of adult criminality, mental illness, and alcoholism could be made from the background and family material; but the physiological indicators were correlated highest with nearly all of the delinquency criteria. Since these physiological indicators are also moderately correlated with later brain-damage classifications, Mednick believes that the EEG and ANS measures are indicants of "brain maturity." All people with "immature" physiological scores do not become delinquents later, so large fractions of the behavioral variance may be due to situational features.

In Copenhagen, Mednick's physiological measurements are obtained from a subject in about 20 minutes, using a computerized equipment and scoring setup. As far as is known, no longitudinal studies using these physiological scores have been done in military populations, but there are some intriguing possibilities along this line. The US Army in Europe sends several thousand soldiers a year back to America for early discharge. Most of these separations are for such reasons as unsuitability, misconduct, and drug-alcohol rehabilitation failure. The US Army Walter Reed research unit at Heidelberg recently tabulated the biographical data from a month's sample (N=649) of these dischargees. As in the Mednick studies, background variables did not predict military inadequacy very well: the early dischargees closely resembled the general USAREUR population in most respects. Certainly there was no "dischargee" profile, though the delinquent sample did tend to be slightly less educated and to have had more disciplinary actions. On the positive side of military effectiveness, Israeli armed forces recently reviewed the records of about 150 "heroes" from the Yom Kippur war. These decorated men tended to be a little more intelligent than a matched control sample, and there was not a single case of AWOL behavior in the hero set; but again there was no distinctive background profile. Careful review of the heroic circumstances indicated that when a certain set of combat conditions hold (own forces outnumbered, but commanding officer still present, etc.), then a heroic act is likely to be performed by somebody, although the designation of just which one will be the hero is near random. Group cohesion in specific Israeli units is often reported to be very strong, which probably raises the likelihood of heroism.

At the University of Stockholm, Carl B. Frankenhaeuser and his colleagues have been using endocrinological measures in their work on subjects under stress. They differentiate between "effort" arousal and "distress" arousal. When effort-without-distress is occurring (as in working on a challenging but soluble mental task), the sympathetic-adrenal medullary system is activated. On the other hand, distress-without-effort (as in a negative but uncontrollable situation) is mainly correlated with pituitary-adrenal stimulation. The states of these arousal systems can be measured by urinary catecholamine and cortisol outputs. The Stockholm results indicate that one key to coping with stress is the controllability of the situation, as perceived by the subject. There are, of course, individual differences in tolerance

to prolonged stress situations. Also at Stockholm, David N. Magnusson has been measuring testosterone (T) levels in delinquent and normal young men; he finds a higher T output in the delinquents, and even higher Ts in those who have committed more violent offenses. Other studies, performed in the US, suggest that some schizophrenic symptoms and perhaps the affective disorders have their basis in catecholamine dynamics.

At the Karolinska Institute in Stockholm, Dr. Marie Asberg has demonstrated an association between brain serotonin and propensity to suicide. Serotonin is a significant brain chemical, and its level can be reliably traced by means of a metabolite chemical called 5-HIAA, which can be obtained in a spinal tap procedure. Asberg's work shows that the level of 5-HIAA is noticeably lower in those who attempt suicide than in other people, and that the measurements have a high ($r = 0.84$) retest reliability across occasions. Furthermore, those who use violent suicide methods (e.g., guns, hanging) are even more likely to have low 5-HIAA levels. Followup studies of a sample of 27 Swedish patients who had been seen in a psychiatric unit, and who had exhibited a low 5-HIAA level there, revealed that 6, or about 22 percent of the sample, had killed themselves thereafter.

Whatever the applicability of physiological predictors in military organizations, the results are not likely to be simple. Mednick's work shows that young men with unresponsive, slow-recovering autonomic nervous systems and with "alpha" EEGs are indeed prone to antisocial activity and failure; but these same physiological patterns are also related to behavior patterns labeled as "fearlessness" and "ability to function under high risk." Perhaps the prediction of military performance, even when valid physiological measures are used, will still have to include group and situational aspects of the work setting, and entirely different equations may be necessary for predicting suitability, say, to technical and to combat environments. (Nicholas A. Bond, Jr.)

SHIFT WORK AND EFFICIENCY

Night work means bad work—mistakes, errors, and sloppy performance by haggard, disgruntled and irritable workers. So goes the legend. It is a fact that most workers hate to be on the graveyard shift. And when radar target search is done by ordinary day-adjusted people, there is a long warmup starting in the morning with gradually improving productivity as the day goes on. Targets are found most efficiently during the evening at 8 or 9 p.m., and least efficiently at 4 or 5 a.m. This applies to other work areas as well. For example, night-shift nurses who were shown a training film at 4:30 a.m. remembered less than half as much as night-shift nurses who saw the film at 8:30 p.m., when both groups were checked for subject matter retention a month after the film was shown. Studies show that graveyard-shift workers lose an average of 7 hours of sleep per week, compared to their dayshift colleagues in similar jobs. There are some exceptions to the pattern, however. Process controllers in a British chemical plant made fewer errors at night than those doing the same work during daylight hours. And in the British Navy, a "post-lunch dip" was observed from 1 to 2 p.m.; during this time subjects showed an above-average error rate, although they recovered in midafternoon and were again at near-optimal performance levels.

Another cherished dictum is that learning proceeds best in the morning; you can learn better because you are well rested and the brain is "fresher." When complex stories were told to school children at 9 a.m. and 3 p.m., immediate learning was, indeed, greater for the morning presentation. But when they were tested a week later, the children remembered more if they had originally heard the story lessons in the afternoon.

The results just mentioned certainly do not fit a simple-minded model of human efficiency under time change. The idea of a direct association between time of day and human efficiency is gradually being supplanted by a more elaborate conception of time and performance. One of the three or four research groups in Europe which concentrates on the performance aspects of human rhythms is the Perceptual and Cognitive Performance Unit at the University of Sussex in Brighton, England (*ESN* 33-2:68 [1979]). Headed by

Peter Colquhoun, the unit is one of three sponsored by the UK Medical Research Council. (The other two are the Applied Psychology Unit, Cambridge, and the Project on Selective and Control Processes in Perception and Memory at Oxford University.) The Sussex unit has about a dozen people on the staff, and publishes many studies every year. Some of the work is quite applied, such as designing a night-work schedule for nurses; other research is directed at the basic chronobiology of man.

One of the unusual findings of the Sussex research was that extroverts tend to adjust more quickly to a radical time-phase shift than do introverts, and if the subjects are further designated (by Eysenck's questionnaires) as "neurotic," the extrovert-introvert difference in adjustment is even more marked. Starting with round-the-clock oral temperature checks, Colquhoun and Condon measured on-shift temperatures of a small group (5 extroverts and 5 introverts) as they adjusted to a new work regime of 10 p.m. to 6 a.m. for 12 consecutive nights. On-shift temperatures rose faster in the extroverts, signifying a quicker adaptation.

Nearly all workers eventually adjust to shift changes, but the adjustment is often incomplete, and different task demands do not all elicit adjustment at the same rate. Much depends on the coordination between physical (sunrise-related) time cues and social (clock-related) time cues. The Sussex researchers substantiated the classical finding that it takes about a day, per-hour-of-time-change, to recover from long-distance flights; the rapid adjustment is apparently explained by the fact that the new physical (sun) time and the social (clock, meal, and work) time are consistent with each other. But when the clock is moved forward one hour for summer daylight-saving time, it takes 3 or 4 days to accommodate to 1 hour of change; in this case the social time indicators (clock and work) have changed but the physical cues have not. The adjustment to daylight saving time, incidentally, was considered important enough by Sussex researchers to justify a check of traffic accidents during the change period. Timothy Monk's compilation of traffic statistics for a period of 8 years showed that accidents were slightly higher during daylight-saving-time changes, but the increase was very small, certainly not enough to justify any reversal of the practice by which daylight-saving time is observed.

In tasks which require many higher order mental processes (e.g., calculation, reasoning), accommodation can be made quickly to a radical shift change; manual dexterity skills take much longer. Simon Folkard, now a Sussex scientist, demonstrated that fact a few years ago with members of an isolated survey group in Antarctica. The finding tied in nicely with some recent work on memory load and body temperature. When the short-term-memory load was small (searching for two specific letters in a long list), performance was directly correlated with temperature: that is, it was best in late afternoon and early evening. But when immediate-memory load was high (six letters), performance was better during the 10 p.m.-6 a.m. time period.

A plot of body temperature often looks like a sawtooth waveform with a cyclic period of one day. In analyzing temperature data from 90 subjects, the Sussex group found that a bisinusoidal model fitted the data quite well. To apply the bisinusoidal model, however, relatively large data sets are required; on a small sample, chance variations may be given weights that result in a "too good" fit for what may be a nonstationary process. The problem appears to be analogous to the estimation of weighting coefficients in discriminant analysis, where a system based on larger data samples and fewer predictors may stand up better than an extremely well-fitted process with many variates.

The Sussex group has compiled much evidence indicating that slowly rotating shifts are undesirable (a slow-rotation system is one in which the worker is on the day shift for a week or more, then on the swing shift for a week, and then on the graveyard shift for a week). Rapidly rotating shifts are recommended for nursing and other round-the-clock occupations. A schedule of two days on a regular shift, two days on swing shift, two night shifts, and then two days off is frequently tried; it is increasingly popular on the European continent and is being used now in American hospitals. As many jobs and tasks become more complex because of increased technological and communications demands, it is generally best for workers to remain day-dominant, that is, for them not to adjust fully to the new shift. And this is just what happens on a rapid-rotation schedule. In fact, the process controllers who performed better at night were on precisely this kind of rapid rotation.

The Sussex research unit does not limit itself to shift-work studies. Simon Folkard conducted a follow-up investigation of the effects of different anesthetic agents on high-level cognitive skills. Minor surgery patients took a battery of tests (logical reasoning, two-digit addition, etc.) before and after surgery. It took up to 3 days for the subjects to get back to their original performance levels. Halothane, one of the anesthetic agents employed, seemed to cause a temporary reversal of normal diurnal performance trends: instead of a rise to midday and a fall thereafter, the pattern was just the opposite.

Two recent signal-detection experiments performed by Angus Craig at Sussex give the flavor of some of the unit's work on human vigilance. In the first study there were two signals to be found, and these differed in conspicuity and also in likelihood of occurrence (.05 and .15) over a given time frame. (A circular display with a "spoke" was employed, and the spoke angle and circular area were varied.) Half of the 48 subjects were told of the signal probabilities; the other half were not told. Over a one hour session, knowledge of the probabilities produced a more stable performance. The second investigation explored the effects of signal mix on detectability. When the searching environment consists of homogeneous nonsignals, the real signals are easier to find than when there is a background mixture of signals and nonsignals. There is thus a strong interference from other signal indications in the environment; and the effect on humans is stronger in those cases where the sought signal itself is especially difficult to find. Such findings have obvious implications for practical display design. (Nicholas A. Bond, Jr.)

CHEMISTRY

PICOSECOND LUMINESCENCE EXPERIMENTS AT THE UNIVERSITY OF BERNE

Berne, the seat of the federal government of Switzerland, lies in a picturesque location inside a loop of the Aare River and facing the Alps.

I visited Dr. Gion Calzaferri at the Institute for Inorganic and Physical Chemistry at the University of Berne. Calzaferri and his collaborator, Heinrich Gugger, have developed a continuous wave (CW) laser technique for measurements of molecular decays of electronic excited states on the picosecond time scale. In this technique, light from the CW laser is intensity-modulated, and an observed phase shift between the excitation beam and emission of luminescence from the sample is used to determine the lifetime of the luminescent species. Calzaferri pointed out that some of the problems associated with determinations of picosecond lifetimes by the usual laser pulse techniques are obviated by using his technique. For instance, with pulse procedures, problems can arise due to excessive power density, which results in optical and chemical nonlinearities as well as secondary processes. Calzaferri emphasized that his technique requires only a few milliwatts of laser power.

Calzaferri noted that the concept of measuring short lifetimes with intensity-modulated light had been considered several years ago; however, with the advent of laser technology, research in this area has received new impetus. The method involves the use of intensity-modulated light to excite a sample, which then emits intensity-modulated luminescence. Although the modulation angular frequency of the luminescence ($\omega = 2\pi\nu$) is conserved, the emission is delayed with respect to the excitation by a phase shift ϕ_τ which can be related to the luminescence decay time τ. For a single exponential decay, ϕ_τ is related to τ by $\tau = (1/\omega)\tan\phi_\tau$. The procedure for a determination of τ involves two measurements of ϕ: (1) ϕ_0, where both chambers contain identical scattering media in order to set a phase null and (2) ϕ_1, where the sample replaces one scatterer. The phase difference $\phi_\tau = \phi_1 - \phi_0$ then represents the phase shift caused by the lifetime of the luminescent species. The absolute accuracy of lifetimes determined with this setup is put at 30-50 ps. Relative measurements can be carried out within ± 15 ps. The resolution of the method is apparently limited by the dynamic calibration of the spectrum analyzer.

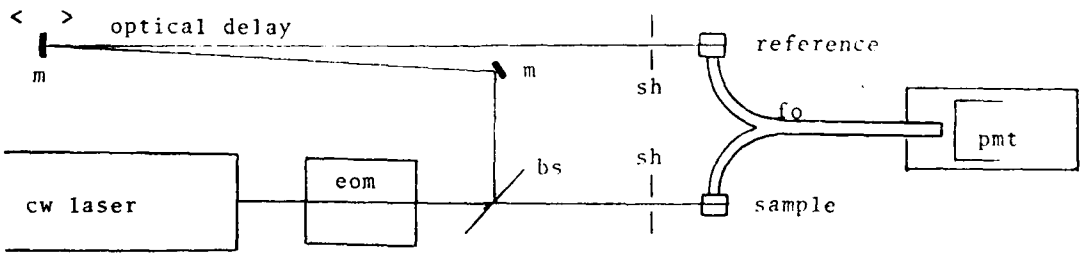
A brief schematic diagram of the apparatus is shown on p. 253. The laser beam (krypton ion gas laser from Spectra Physics, Model 171) is intensity-modulated by a Coherent Associates 3050 electrooptical modulator. The beam is subsequently split by an uncoated quartz wedge to give a transmitted beam (90%) which enters the sample chamber and a reference beam (5%) which is deflected to an optical delay line. The reference chamber contains a magnesium oxide diffuser

which reflects the beam onto the optical fibers to provide a phase reference. The reference beam and the luminescence from the sample are individually collected by fiber optics, the fibers of which are homogeneously mixed to give a single cable. The combined light is directed onto a five-stage RCA 31024 end-on tube. Calzaferri pointed out the considerable advantages in construction due to the fiber optics, and he emphasized the fact that the light path from the reference and sample chambers to the PMT remains fixed and therefore needs no readjustment. In addition, the idea of guiding the light to a small spot (8mm) at the center of the PMT eliminates problems of cathode nonuniformity and slight beam deviations that could develop during measurements. A further advantage: compared to full-size illumination of the cathode, center-spot illumination reduces the electron-transit spread.

The data in these experiments are acquired by a Tektronix WP 2222 waveform processing system with a digital processor oscilloscope. The scope is equipped with a 7L13 spectrum analyzer that provides 30 Hz resolution for frequencies up to 1.8 GHz. As the spectrum analyzer provides only relative frequency measurements with high precision, the original sine-wave generator for the intensity-modulation of the laser beam has recently been replaced by a Tektronix TR501 tracking generator. Control of the experiments and data processing is handled by a PDP 11-05 computer.

Calzaferri and Gugger have recently conducted a series of dual-beam luminescence experiments with the system described above. These experiments were designed to probe small changes (< 20ps) of radiative lifetimes in the nanosecond range and have served to test the reliability of the time resolution of the apparatus. Fluorescence quenching of Rhodamine B in 90% ethanol by potassium iodide was chosen for study. Two identical sets of dye solutions of varying concentrations of the quencher were prepared. In a "chess-board-like" procedure, the fluorescence lifetime of every solution of one set was compared with that of every solution of the other set by placing one in the reference and one in the sample chamber. The result of each comparison gave a lifetime difference. The radiative lifetime and the quenching rate constant could then be calculated from these data. Calzaferri noted that the dual-beam nature of these types of experiments is critical to the measurement of small changes in relaxation kinetics in the picosecond or nanosecond range. He indicated that this method should also be applicable to investigations of the influence of temperature, viscosity, solvents, and energy transfer.

Another area of research in Calzaferri's group involves the conversion of solar energy into chemical energy. They have recently been investigating a silver chloride photoredox system which seems to have very good storage capacity. UV irradiation, in 0.2 M NaCl and 0.05 M HCl electrolyte, of a zeolite electrode containing silver cation produced silver and molecular chlorine, and gave a cell with a short circuit potential of 1.1V. Currents of 0.1 mA/cm^3 at 700 mV have been measured between the silver electrode and a carbon electrode. There are still some problems to be solved: the colloidal silver that is formed should be coupled with another reaction in order to extract the full chemical potential of the cell. In addition, for practical applications, this reaction will need to be sensitized so that visible light can be used. (A. Paul Schaap)



Schematic diagram of the apparatus: bs, beam splitter; m, mirror; eom, electrooptic modulator; pmt, photomultiplier tube; fo, fiber optics; sh, shutter

COMPUTER SCIENCE

UK's MINISTRY OF DEFENSE COMPUTER STANDARDIZATION POLICY—A COMPARISON

Introduction

In 1978, this author was directing the Computer Family Architecture (CFA) project at NRL as part of the US Army/Navy computer standardization program. Through arrangements made by ONR London, a series of visits were made to several UK Ministry of Defense (MOD) establishments to learn about the "MOD Computer Policy" and to exchange technical and planning ideas. Both the UK and the US programs were similar in intent. To date, progress has been made on both sides of the Atlantic. However, differences in the approaches made to the problem by government, on the one hand, and industry, on the other, greatly influenced the divergence of implementation results.

The three establishments actively involved in the MOD Computer Policy and their particular areas of concern are: the Admiralty Underwater Weapons Establishment (AUWE), Portland - Equipment Practices and Instruction Set Architecture; the Admiralty Surface Weapons Establishment (AUWE), Portsdown-BUS and I/O Channels; and the Royal Signals & Radar Establishment (RSRE), Great Malvern - Software.

The promulgated MOD computer policy mandates the following common procedures for all the services:

(1) The same standard equipment construction practices for all units, based on the double "EUROCARD" made to military specifications, will be used.

(2) A 2-card military computer, based on the commercial Ferranti ARGUS 700 instruction set has been developed. This computer is to be used as the main system computer.

(3) A new bus, EUROBUS (originally called MODBUS), which has been developed for close-coupled systems, will be used.

(4) The ASWE multi-drop serial data highway has been developed for subsystem interconnection. This type of serial data link including US MIL STD 1553B will be adopted as the interface standard.

(5) All software will be written in the high-level language, CORAL 66 (Computer On-Line Realtime Applications Language).

(6) Modular structured programming methodology will be enforced for software production, operation and testing via MASCOT (Modular Approach To Software Construction, Operation and Testing).

Standard Equipment Construction Practices

When proposals to use the same modular 2-card standard embedded computer for various military systems were being formulated, it quickly became apparent that the form factor of the standard computer could not be specified without also specifying the equipment construction practices including interconnection, power, cooling, and housing specifications. AUWE felt that the wide use of these computer cards within both surface-ship and submarine systems implied a common equipment practice for those two branches of the Royal Navy. It has proven difficult in the past to ensure that even one contractor used the same equipment practice on consecutive projects. The logistic advantages are obvious. Many existing equipment practices were examined. In the end, it was decided to select the standard 19" rack with commercially available single and double EUROCARDS (100 x 160 mm and 233.4 x 160 mm) as the basis for the equipment configuration. The basic unit is one "shelf". Each shelf contains its own power, cooling, and interconnection arrangements. Multi-height cabinets can be configured by stacking these shelves. Air-cooled and conduction-cooled versions have been developed. For avionic applications, the ATR (Air Transport Relay Rack)-version of EUROCARD housing is under consideration. Joint arrangements were made with the three major contractors (Ferranti, Marconi, Plessey) spanning the Navy applications to share in the development of a new military equipment practice, and all three are now committed to use the practice for system applications. Since the development was funded by the MOD, it will be made available to all companies (for either military or commercial applications) in 1982.

Government-industry cooperation of this sort is not practical in the US. In our system, production technology, packaging, and equipment practice involve intensive capital investment. There are at least 22 qualified military computer manufacturers in the US. Packaging standardization could be interpreted as a step away from free competition and as a hindrance to innovation, despite its obvious logistic advantages. The joint ARMY/NAVY CFA/MCF (military computer family) project has considered

this aspect of the practice in conjunction with the Electronic Industries Association (EIA). To the knowledge of the author, no workable conclusion resulted from the many committee meetings since 1977.

ARGUS M700

In 1977, the MOD decided to develop a replacement for their standard Navy computer, the Ferranti FM 1600B. The consensus at that time was in favor of developing a "modular" computer of equivalent power but greatly reduced size, and with improved reliability, rather than to push technology to the limit to produce a much more powerful computer. The intent was to develop a system which distributed software functions among embedded subsystem computer modules. In order to reduce the long lead time and the cost of support software (compilers, system generation software, etc.), the decision was made to use the instruction-set architecture of an already successful family of computers which had proven support software. Furthermore, the choice of instruction set was limited to those of minicomputers with a 16-bit word length from domestic suppliers. The Ferranti ARGUS 700 instruction set was finally selected.

The ARGUS M700 processor consists of 2 double EUROCARDS, with a third card to provide 32K words of private memory. This is a minimum configuration which can either stand alone or be connected to the EUROBUS to access shared memory or other system components. More than one M700 processor can be connected to the same EUROBUS.

The ARGUS instruction set is claimed to be optimized to support the CORAL 66 high-level language. This claim may or may not be valid. However, the complexity of the instruction set definitely will discourage the uninitiated from attempting to program the system using low-level assembler code. This has the desired effect of enforcing the high-level programming language policy.

The instruction set is implemented by microprogram. Microcode was written and controlled by AUWE to insure compatibility. Diagnostic and monitor functions are also implemented through microcode. AMD 2901 bit-slice chips are used together with PROMs and programmable logic arrays (PLAs). AUWE simulated the entire processor down to gate level on a PDP-11/45 computer. The design was verified prior to its construction by running the diagnostic routines of the target machine on the simulation system. The paper tapes required for programming the PROMs and the PLAs in the new M700 design are generated as the result of the simulation. Thereby, the design of the new computer is reduced to an interactive software exercise. Ferranti was awarded the initial hardware development contract. Fifty computers have been delivered, and multi-source production drawings will be available in 1982.

In the US, the DOD's CFA project had also selected a proven commercial instruction set architecture, namely that of the DEC PDP-11. The rationale was the same as that used by the UK MOD. However, the DOD failed to negotiate a satisfactory licensing agreement with Digital Equipment Corp. In the CFA evaluations, it was concluded by benchmark simulation that the Navy's standard minicomputer (AN/UYK-20) instruction set is equivalent, if not superior, to that of the PDP-11. In view of the already incurred costs in existing support software and application software for AN/UYK-20 and AN/AYK-14 systems, a replacement computer development, the AN/UYK-44, was initiated also using AMD 2901-family chips packaged on standard electronic modules (SEM). Prototypes are currently under test.

EUROBUS

The EUROBUS was originally named MODBUS. Its wide acceptance in European Common Market countries with the EUROCARD equipment practices became the *de facto* European bus standard. This was one case in which a successful standard was accepted by the community, not enunciated by policy. A considerable amount of effort was spent at ASWE to develop the new bus. The EUROBUS is the primary bus for communications between the processor, memory, and peripherals. The use of a minimum number of wires was the most important design criterion because of connector-pin limitations. The important element of the bus is the arbiter. The arbiter is designed to allocate the bus facilities among competing devices: processors, memories, peripherals, etc., on a bus-cycle basis. Address and data words are multiplexed to share the same lines. Bus allocation and operation are fully overlapped. Only 28 lines are used in the EUROBUS. Assorted memories, cores, semiconductor PROMs, etc. packaged on EUROCARDS can be interfaced with the EUROBUS.

A set of three 40-pin integrated circuit chips has been developed by Ferranti (2nd source: Marconi)

to perform the interface protocol and control functions with EUROBUS. The chip set provides the asynchronous "handshake" and error monitoring when appropriate. A wider data bus interface can be accomodated by adding an extra 40-pin chip for each additional 8-bits of data "width". This chip set provides a wide variety of users with easy access to the EUROBUS, interfacing with different special-purpose system devices. A standard bus interface has been devised.

On EUROBUS, read-write cycles are supported with a 256K address space for 16-bit data words. Byte addressing is also supported. In addition, a pseudo-address space of 256K words is provided for peripheral and interrupt transactions. Simple peripherals can notify the bus arbiter to generate processor interrupts. There is a vector interrupt cycle that has only an address (interrupt vector) in the pseudo-address space, but no data. This allows a designated slave operation to occur asynchronously through the address-output side of the interface chip-set.

Two or more EUROBUSES, each operating asynchronously with its own arbiter, can be linked together by one or more bus linkers (another EUROCARD) so that a device or processor on one bus can access a device or processor on another bus. The bus linker is transparent to the user. However, each bus must have an assigned priority which will enable the arbiter to allocate, suspend or deallocate the bus cycle via the interface chip-set. For more than 2 buses so connected, the BUS linkers are chainlinked.

The easily accessible ("exposed") EUROBUS approach together with the EUROCARD equipment practice makes the MOD computer policy an attractive alternative for the user. Facilities are provided for easy user interfaces, and the wide acceptance it has received in the absence of feasible alternatives has led to standardization virtually on a voluntary basis. When this type of system has been adopted by other countries, namely Canada, Australia and New Zealand, the author will not be surprised to see US equipment built with interfaces consistent with the EUROBUS, considering the desirability for interoperability of systems and spares within NATO and other allied organizations.

Digital Highways

In computer terminology, the bus does not run on highways. On the contrary, highways are connected to the bus. These are data highways. ASWE adopted two serial digital links to use with the EUROBUS for this purpose. The US military standard (MIL STD 1553B), which is a very well defined data channel adhered to by several LSI manufacturers who produce interface chip sets, has been adopted by ASWE, despite its recognized weaknesses. This provides easy access to the EUROBUS by American devices. A high-integrity serial link with broadcasting capability and with twice the 1553B bandwidth was designed at ASWE. To date, it has not met with wide acceptance. Therefore, it has not yet been enforced as a MOD standard.

Application System Modules

The EUROCARD and EUROBUS standards enable system designers to use existing hardware modules and interconnection standards together with standard support software (described below) to develop and to integrate their application systems in the most expedient manner. Since EUROCARD is the smallest replaceable assembly (SRA), this will reduce the total number of SRA types for a given system. For instance, AUWE forecasted that over 90% of the next generation of sonar systems could be configured by using fewer than 50 EUROCARD types (too many!). A double-EUROCARD fast-Fourier transform and filter unit and a programmable acoustic beam former have been integrated and tested at AUWE. These are PROM-controlled special purpose digital signal processing modules.

Software

The high-level language, CORAL 66, originally developed by RSRE, is a mature language. It has been in existence since the early 70s. It is a stable language, and is widely accepted by the UK's MOD and Department of Industry. In fact, it is the programming language for the commercial version of Ferranti's ARGUS 700 computers. CORAL 66 is an ALGOL-like language with separately compilable blocks which provide linkage to object segments outside a CORAL program. Therefore, it can adopt a new programming language in an evolutionary manner. The MOD is waiting for the US DOD's high-level language "Ada" to come into existence. When the "Ada" language is stable, its marginal utility can be evaluated quantitatively. Then, with its support software in place, MOD plans to bring "Ada" into its standard language inventory. This again points out the wisdom of adopting an existing standard without incurring the undue risk of developing a new standard.

MASCOT is a methodology to enforce structured design in all phases of software development. As originally conceived in RSRE, all complex software tasks can be expressed in a network diagram form using three entities, namely, activities, channels, and pools.

An activity is an independent asynchronous software process. It is a single-thread process run in parallel or in sequence with another process. Activities are interconnected with well-defined ports called channels and pools. A channel is a buffer with input and output ports. Several activities can be connected to the input of a channel for passing messages into the channel. The output port is normally connected to only one activity. Semaphores are used to synchronize input activities. A first-in-first-out control queue is automatically established to claim the channel input port. A pool operates like a channel except that it stores permanent or semipermanent data while a channel is only concerned with data in transit.

When a system designer describes his software development task as a network of activities interconnected by channels and pools, he then proceeds to specify each activity as a separate program task to be assigned to a programmer. The system designer writes and controls channel and pool software; therefore, he defines the explicit input and output messages to and from an activity and he also controls synchronization and the access of activities. In this manner one can view the MASCOT network as a data-packet-driven network. MASCOT provides a small kernel for scheduling activities and managing semaphore synchronization. This kernel is actually the operating executive on the ARGUS M700 system.

Both MASCOT and CORAL 66 are machine independent. For the ARGUS M700 system, software development systems are supported on either the commercial ARGUS 700 or the PDP-11/VAX 780 systems.

The closest existing equivalent to MASCOT in the US is the NRL-developed Common Realtime Operating System (CROS) with the ASW Common Operational Software (ACOS) using SPL/I (signal processing language) for the AN/UYS-1 and AN/UYK-20/44 families of computers. The author fully endorses the MASCOT concept.

Summary Comments

Lessons can be learned from the MOD's successful realization of its computer policy. First, the policy is eclectic in adopting existing *de facto* standards, and in allowing its systems to embrace new developments without exposing itself to the high development risks. Therefore, the policy is noncontroversial in the user community. Three UK government establishments divided the entire technical task into interrelated and interdependent areas, and technical consensus was achieved among all the units involved. Relationships between MOD and UK industry were remarkably good, as is shown by multi-source system components with a common equipment configuration and EUROBUS interface. The situation is radically different in the US, where it is almost impossible to reach consensus among all interested parties and competing organizations for computer standardization efforts. Perhaps EUROBUS has shown the way. The MOD establishments and the UK's industrial organizations that were involved in this truly cooperative and productive effort deserve our congratulations. (Y.S. Wu)

ENGINEERING

MICROWAVE RESEARCH IN TOULOUSE

The "grandes écoles" of France are institutions of higher learning which are specially geared to technical and managerial subjects. Entry is highly selective and competitive, whereas admission to a university is open to any high-school graduate. Before an engineering school is recognized as a "grande école" it must be approved by a special commission, and it is then usually under permanent sponsorship by a ministry. Sometimes a grande école may be recognized by its title, in which case it will include the wording "école national supérieure."

ENSAE, the Ecole National Supérieure de l'Aeronautique et de l'Espace (aeronautics and space) is a grande école which is situated in Toulouse and is tied in with the Ministry of Defense. It includes a special organization for its staff and postgraduates to carry out research work, the Toulouse Research Center (CERT-Centre d'Etudes et de Recherches de Toulouse). The Center is divided into 7 departments, one of which is the microwave department, DERMO, (Département d'Etudes et de Recherches en Micro-Ondes). Students come to this center with the equivalent of an MS. They usually spend about 2 years there and earn a doctorate in engineering.

The purpose of my visit was to see Prof. Léo Thourel, of ENSAE, who is also director of DERMO. At DERMO he is involved both with students, directing their thesis work, and with research work, which is promoted mainly by the Department of Defense and which is frequently classified. Further support comes from other government and industrial organizations. DERMO employs 35 people; most of them also work for ENSAE, where about 60 engineering students graduate annually, and where Thourel teaches "hyperfréquences" (which he defines as the spectrum from 300 MHz to 300 GHz and which includes microwaves). The research work at DERMO falls into three categories: antennas and radomes, microwave components, and industrial and medical applications.

The antenna work at DERMO includes a study of the performance of parabolic reflectors, which are fed with corrugated feedhorns for improved efficiency. The initial theoretical calculations included only the reflector. Next, the diffraction of the feed was added, and lastly the diffraction of the feed supports was taken into account. GTD (geometric theory of diffraction) was used to calculate the response, except for the region of the main beam, which was derived using the aperture field method, and the supports, whose contribution to the field were calculated using equivalent currents. The theoretical results for an X-band system with a 3.3 m diameter reflector were compared with experimental measurements, and it was shown that the agreement improved as the additional correction factors were taken into account, deviations eventually being within a few dB for levels as low as -60 dB. The calculations were then extended to investigate tolerances of reflector shape and position, and cross-polarization effects.

Other antenna studies included the development of a 70 GHz monopulse tracking system. Two designs were used. In the first, the primary feed was a circular corrugated horn which gave over 70% efficiency for the sum channel; however, the difference pattern gain was 12 dB below that of the sum pattern. A rectangular horn was then tried. This horn brought the gain of the difference pattern to within 3 dB of that of the sum pattern, but the sum pattern efficiency was reduced to 43%. A different circular corrugated horn was developed for another program to match two widely separated frequencies (14 GHz and 23 GHz). This was achieved by superimposing two sets of grooves. In another project, multifeeds in the focal region of a reflector were combined to give a shaped beam.

DERMO acts for the French Navy, and has both design and test responsibilities for radomes. The department's interests include radomes for Mach 7 missiles, where the requirements involve thermal shock measurements using mirrors that focus the sun. For aircraft radomes, transmission and reflection coefficients as well as reflection lobes are both calculated and measured. The work is both theoretical and experimental.

Various microwave components have been developed at DERMO. Among these was a 50-kW CW S-band circulator; it was designed for Thomson CSF, for an industrial application which uses a klystron.

Dielectric-constant (ε) and loss tangent ($\tan \delta$) measurements are important to characterize dielectric materials. Samples are normally placed in a cavity, but this type of measurement becomes difficult at millimeter wavelengths because of size and tolerance requirements. An open-air quasi-optical cavity has therefore been developed at DERMO for such measurements, and it was described to me by Thourel. The design consists of two curved reflectors that face each other. The reflectors are spherical in shape, although other shapes are quite possible, and share a focus at the midpoint between them. The dielectric sample is placed on the axis near the focus and the changes in resonant frequency and Q are noted. Accuracies of about 1.5% in (ε-1) and 10% in $\tan \delta$ were claimed at frequencies as high as 94 GHz (3 mm). Liquid samples could also be measured with this setup.

A PIN-diode mm-wave phaseshifter was being developed for the frequency range of 60-90 GHz. For this, 3-5 diodes were cemented together to give a "diode de rideau" (diode curtain). The diodes sat one on top of the other in the E-plane, along the side wall of a flattened waveguide. The diode package was typically 300-500 μm wide, 300 μm high, and 1 cm long. Insertion loss and phaseshift varied with the bias; losses were low with zero current or with saturation current. A phaseshift of as much as 300°/cm was predicted theoretically, but so far only about 50°/cm has been achieved with a VSWR (Voltage Standing Wave Ratio) of less than 1.2. The insertion loss of 3 dB was also appreciably higher than the expected value of 1 dB. The group is working with Thomson CSF and is trying to develop more suitable diodes. The power potential of these phaseshifters is not known at this time, but is expected to be in the kilowatt range.

In the field of industrial microwave applications a very intriguing and unexplained phenomenon was found. Microwaves were used as energy sources for the polymerization of plastics. Specially formulated, lossy plastics were used to generate internal heat when irradiated. It was found that polymerization was obtained with only a small fraction (2⅛%) of the energy normally required for this process, and, furthermore, the process was speeded up fourfold (down to 1½ hours instead of 6 hours). These surprising experimental results are not yet understood. The work is supported by the French Electricity Authority and it clearly could be of considerable importance. In another applications program, the microwave irradiation of soil to kill weeds was investigated.

Thourel showed me through the Microwave Medical Applications Laboratory where several programs were underway, usually in cooperation with a medical school. Some tumors have been found to be susceptible to microwave radiation treatment. If irradiated, they absorb more heat than the healthy areas, which are better cooled by blood. Tumors have been found to be rather sensitive after such irradiation and to show an enhanced response to subsequent treatment with cobalt. For the irradiation, a 200 W CW source operating at 470-860 MHz was available at the laboratory. A start has been made on the design of an applicator that could match water which, it was said, gave a response not very different from that of human tissue. The use of microwaves for medical imaging was studied for a system using a fixed transmitter and a scanned receiver with the object between the two. Image formation will be attempted by a reconstruction using the amplitude and phase variations of the received signals as a function of position and it is hoped that this can be done in the span of one hour. An experimental imaging system was tested that consisted of an object in a tank of water which simulated the human body, with a transmitter on one side and a receiver on the other. Rather than moving the antennas, the object was moved, and images were obtained.

The effects of low-level microwave radiation were studied with mice, which were exposed to levels varying from 10 μW to 10 mW for periods extending from several hours to several days. After exposure, the animals were sacrificed, and tests were made of the blood, metabolism, adrenalin, cholesterol, and other physiological indicators. Very few glandular effects were found at these low levels, but some of the tests seemed to produce measurable changes, and these are being studied.

Thourel is approaching retirement age, but DERMO will undoubtedly continue to be France's leading academic microwave research organization, and to carry on in the tradition that has established its high reputation. (T.C. Cheston)

UNIVERSITY OF TEL AVIV AND THE TECHNION: FROM SEISMICS TO OPTICS

This article summarizes some of the work observed by the author at the University of Tel Aviv and at Haifa's Technion. It is a potpourri of items in the general area of radiating systems.

My first visit was to see Dr. Mark Beran, originally from Pennsylvania State University, who is professor of engineering science at the University of Tel Aviv, Israel's biggest university with more than 15,000 students. The Engineering School has about 1,000 undergraduates. It is divided into 5 departments, including one devoted solely to solid-state devices and another that covers "interdisciplinary studies" and provides a home for budding programs. Beran works on acoustic problems. He was one of the prime movers in organizing the International Symposium on Underwater Acoustics, sponsored by the university's School of Engineering, that took place in Tel Aviv in June 1981 with much UK and US participation.

Beran is primarily interested in scattering due to turbulences or internal waves; such scattering applies to electromagnetic and optical transmission systems as well as to acoustics. His secondary interest is in caustics which are encountered in acoustic propagation in the ocean and are the result of the partial focusing of acoustic energy due to the variation of velocity of propagation with depth. Caustics are zones of highly concentrated energy and therefore are of considerable interest since they define regions of enhanced detection capability. Geometrically, with ray tracing, a caustic is the envelope of the intersection of adjacent rays. Beran claims to have derived representative equations which he intends to solve, using real oceanographic data.

Dr. Steve Blank works on array-antenna radiation-pattern optimization

at Tel Aviv University's Department of Mathematical Science. I had heard of his work from Dr. Thomas apRhys at NRL. Blank also comes from the US, where he obtained both an MEE and an MS in mathematics; his PhD in engineering was from Tel Aviv University. Blank has developed a method for optimizing an aperture distribution with an algorithm which he calls "empirical-optimization." He uses experimental data from measurements of individual aperture elements which include mutual coupling and scattering by the element environment. His optimization method is an iterative process, and rapid convergence is claimed. The optimization criteria are flexible and can include beam-steering, bandwidth, element thinning, beamwidth and sidelobes, as well as beam-shaping, gain maximization and null-steering. In one case, an array of 15 uniformly excited elements with one wavelength spacing had its radiation pattern improved by a change to nonuniform spacing. This not only suppressed end-fire grating lobes, but also reduced all sidelobe Maxima to a level of about -16 dB.

The Technion in Haifa is Israel's prestigious institute of technology and has renowned faculties in engineering, science, and medicine. It has a total of some 8,000 students and provides an overwhelming majority of the country's engineers. The Electrical Engineering Department was described by David K. Cheng in these pages several years ago (ESN 30-10:447 [1976]).

Dr. S. Raz is an associate professor at the Technion and also holds appointments at the Seismic Acoustic Laboratory of the University of Houston. Raz spends about half of his time on research. His main efforts have been in the area of inverse scattering where the measured field, defined by the phase and amplitude of signals over an aperture, is inverted. The objective is to reconstruct, by retracing, the original scattered field in order to derive an image. Applications range from nondestructive testing of materials to imaging of organs for medical purposes. Raz's involvement is in acoustic seismic work. This is of prime economic importance: it plays an important role not only in mapping and defining the strata of mining areas, but also, and more relevantly, as a major guide in oil exploration, indicating the most promising sites for drilling, both offshore and on land. In that work, an acoustic pulse is generated, scattered by underground discontinuities, and received by many separated receivers. Migration (i.e., focusing) is made difficult by the lack of knowledge of the velocity of propagation. Raz pointed out that scattering occurred, due to inhomogeneities in the velocity of propagation and to changes in density, and that a multistatic system had the capability for resolving the two. He has developed a migration technique in which he has abandoned the attempt for an exact inversion but has developed an approximate procedure. He claims to have shown that this procedure leads to a superior integration scheme that inherently includes some of the methods that were empirically found advantageous with other schemes. His major departure from existing techniques is in the a priori choice of "background" against which the perturbations are reconstructed for imaging. He proposes a unique background selection in the form of a z-dependent WKB (Wentzel-Kramer-Brillouin) reference, and claims that this overcomes difficulties of the previous methods and provides a more accurate reconstruction. Since then, Raz has presented a paper on this subject at the 50th Anniversary International Meeting of the Society of Exploration Geophysicists (Houston, Texas, Nov 1980).

In the office next to that of Raz I found (not quite by accident) an old friend, Dr. Sidney Cornbleet from the University of Surrey (see ESN 34-7:328 [1980]). He was spending several months at the Technion working on microwave/optical systems and extending some of his previous work. He is now back in England.

One of Cornbleet's studies involved cylindrical lenses with radially varying dielectric constants; the flat faces of the cylinder formed the input and output apertures. A doublet was formed by joining two dissimiliar lenses of this type by bringing two of their respective flat faces together. Interesting and perhaps unusual results can be obtained in this way. In one configuration, the dielectric constant decreases with the radius in the first lens, but increases with the radius in the second lens. With one set of parameters, such a doublet will focus a bundle of rays incident parallel to the axis and filling the first lens, into another bundle at the exit aperture, also parallel to the axis, but completely contained within a smaller radius. Cornbleet calls this "parallel ray focusing." With different parameters, the bundle of rays can be brought to a point focus at the exit aperture of the second lens. This last combination, which he calls

"small-angle focusing," has the characteristic that the bundle of rays at the focus are all within a narrow cone, typically 60°, much less than is found in conventional systems of similar f/D ratios.

In a previous study Cornbleet had compared nonuniform refractive index lenses with equivalent geodesic lenses. These two types can be directly related, using a standard transformation, and equivalent configurations can be found. He calculated a whole series of optical components that become realizable and which are analogous, for example, to waveguide variable power dividers, directional couplers, magic Ts, and ring resonators. A beam divider (or combiner) could, for instance, be formed by a circular disc in which the refractive index varies as a function of the radius, such that two parallel beams from two directions are brought to a focus at the same point. A device of this sort could be used as a mixer by adding a signal in one beam to the local oscillator output in the other. This work has been published recently (*Proc. IEE*, Vol. 128, Pt. H. No. 2, April 1981). (T.C. Cheston)

MATERIAL SCIENCES

EUROPEAN R&D IN BIOMATERIALS

Research laboratories in Great Britain and on the continent have accelerated their development, testing, and introduction to clinical practice of many useful concepts for the design of biomedical devices. Together with laboratories in Japan, they have now assumed leadership roles in some fields of biomedical materials. Attesting to this new prominence of European research in the medical and dental prosthetics area, the First World Biomaterials Conference was held in Vienna, Austria, in May 1980. It was jointly hosted by the Society for Biomaterials of the US, by the European Society of Biomaterials, and by founding committees for similar organizations in Japan and Canada. It is revealing to note that the first professional organization in this field, the Society for Biomaterials, has used the word "for" rather than "of" in its title deliberately to avoid the acronym SOB, which is often applied by other scientists to pioneering workers in biomaterials research.

Another indication of the independent spirit and entrepreneurial attitudes now prevailing in Europe are the publishing and industrial efforts that are emerging. A new journal, *BIOMATERIALS* (Pergamon Press, Oxford, England), was started in 1980; it may be perceived as a European analogue to the *Journal of Biomedical Materials Research* which has been published in the US for some years. Springer-Verlag Press, Heidelberg, FRG, started a series of relevant specialty volumes with the well-received *Boundary Phenomena in Blood Vessels*, which reported the proceedings of a conference held in Bavaria in 1977 on new materials for cardiovascular grafts. The Max Planck Institute, Aachen, FRG, under the leadership of Prof. S. Effert, is almost wholly devoted to research in this field and provided the organizational staff for the conference, which also enjoyed generous funding from the West German government. The giant Hoechst chemical organization, Frankfurt, and the West German government are sponsoring research efforts in the synthesis and tailoring of new polymers for various blood and tissue-contacting applications. Dr. Paul Fischer is Hoechst's leading scientist in this area; the laboratory's work has been well received.

The dental and orthopedic appliance fields share a common interest in the interactions of metals and polymers with hard biological tissues such as teeth and bone. World leadership in the development of permanently fixed artificial hip prostheses is conceded to the clinical laboratories of Dr. John Charnley (Wrightington Hosp., Appley Bridge, Lancs, UK). His technique, which is now universally employed, bonds the metallic substitute hip parts into the bone by using a doughy version of dental polymethylmethacrylate. Prof. J. Brandemark (Univ. of Gothenberg, Sweden) has perhaps the best clinical record for successful implantation of secure dental anchors into the jawbone; his success rate is attributed to the use of meticulously prepared titanium surfaces. Prof. Per-Olof Glantz (Univ. of Lund, Sweden), now serving as head of the Prosthodontics Department at the university's Dental School in Malmo, is internationally recognized as a leader in the understanding, prediction, and control of adhesive phenomena in the oral cavity, upon which all successful dental restoration depends. Among the UK experts who deal with the dental adhesion problem, and especially with the basic formation mechanisms for dental plaque and calculus,

are Dr. S.A. Leach (Univ. of Liverpool) and Dr. V. Tatevosian (Univ. College, Cardiff, Wales). Dr. H. Newton in London is a dental researcher who has perhaps the most complete European collection of examples of the influence of microbial adhesion and action on oral disease processes.

Other highly regarded European research/development efforts in the dental biomaterials area are those at the Nordic Institute for Dental Research, Oslo, Norway, and at the Swedish Institute for Surface Chemistry, Stockholm. Prof. J. Arends (Univ. of Groningen, The Netherlands) is an authority on the crystal physics of hydroxyapatite, the main calcium-phosphate mineral of teeth and bone. One of his recent PhD students, A. Juriansse, has extended the mineral-based approach of Arends to include the spontaneously acquired organic pellicles (absorbed from saliva) that form on the mineral base. Juriansse has recently joined the applied research program of Unilever in Holland. At the same time, the Unilever organization in Britain has lost to academia one of its leading scientists in the same field, Dr. Paul Rutter, who is now with the University of London. The Unilever organization remains a major source of funding and technical expertise in Britain's biomaterials domain; it has recently completed a major industrial-university cooperative research program on this topic with the University of Liverpool. At that university, in a project led by Dr. Keith Gilding, a chemist, a whole new range of new and exciting polyurethane elastomers has been created. These materials promise a myriad of biomedical applications. One such application, pioneered by the British cardiovascular surgeon Easton, uses spun fibrous mats of polyurethane base stocks to produce small-vessel substitutes for the reconstruction of diseased arteries in humans. Until truly synthetic substitutes for human vessel reconstruction are widely available, the best clinical choice may be the stabilized human umbilical cord vein prostheses which are marketed throughout Europe by Meadox Prosthetics, Ltd., Great Missenden, Bucks, England.

Many European concepts in the biomaterials area will be described fully in a major series of texts edited by Dr. D.K. Williams (Univ. of Liverpool). It is hoped that these compilations will include the advances made in the university laboratories and industries of southern Europe. One prominent example from Italy is the pioneering work of the research team led by Profs. A. Marconi and E. Mantovanni of the Snamprogetti group. This group is working on the immobilization of functional enzymes at the surfaces of nylon fibers; progress in this area should enhance the effectiveness and safety of biochemical processing on a large scale.

With all the attention given to the rapid pace of artificial organ development in the US over the past decade, it may surprise some people to learn that research teams in Berlin and Vienna may be the first to succeed in the effective long-term implantation of artificial human hearts. Indeed, the most recent international conclave of experts in this field was held in West Berlin in 1980, in recognition of the significant gains made by European groups within just a few years. Some European research programs in biomaterials development are virtually without peer in the US; one example is the program directed by Dr. Pierre Rey at the University of Paris, in which a successful artificial bladder was fabricated. Rey's work received a top scientific prize from the American Society for Artificial Internal Organs in 1979.

All of these applied efforts are backed up by a substantial number of basic research projects throughout Europe. A prominent example is provided by the continuing program of the Institute of Macromolecular Chemistry at the Czechoslovakian Academy of Science, which is headed by Dr. Jaroslav Kalal. This research institute, under the leadership of the polymer scientists Winterlie and Kim in the 1960s, produced the first "soft" contact lens. Another Czechoslovakian achievement was breast protheses based upon modified versions of common polymethylmethacrylate; these materials can take up nearly half their original weight in bound water. At the Battelle Research Institute in Frankfurt, Dr. Roland Reiner leads a European group in the design and evaluation of new surface-modified polymers for a variety of biomedical demands. In Copenhagen, Prof. K. Birdi provides excellent fundamental support in surface science to the entire European scientific community. At the Karolinska Institute in Stockholm, Dr. Rolf Larsson, who directed the development of new polymer versions that bind blood-thinning anti-coagulants to their surfaces, has also studied an extraordinary range of sophisticated surface characterization and analytical techniques which are now increasingly required for these programs. Prof.

Alexander Silberberg (Weizman Inst., Israel) devotes his research toward a firm foundation of basic polymer chemistry and physics for the applied biomaterials programs.

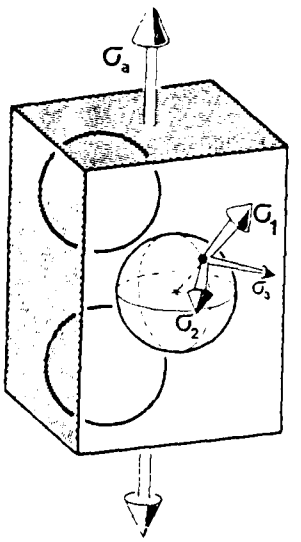
European reports on many of the topics listed in this article will be presented at an International Symposium on Polymer Chemistry in New York City in August, 1981; the symposium will be held in conjunction with the annual meeting of the American Chemical Society. (Robert Baier, Calspan Corporation, Buffalo, NY)

POLYMER SCIENCE AT BASF

The Badishen, Anilin- & Soda-Fabrik AG officially became BASF in the early 1970s. It is one of the largest chemical companies in the world manufacturing basic chemicals: acetylene, methanol, ammonia, solid inorganic chemicals, petroleum derivatives, synthetic fibers, paints, plastics, surfactants, and many other products. It has affiliates worldwide; those in the US are BASF Wyandotte (Wyandotte, MI) and Badische Corporation (Williamburg, VA); the latter had been a joint venture with Dow Chemicals but is now wholly owned by BASF.

The corporate headquarters and central research laboratories are located at Ludwigshafen am Rhein just outside of Mannheim, FRG. I visited the BASF laboratories at Ludwigshafen to learn about their research in polymer science. Although by mistake I arrived a day earlier than expected, my host, Dr. Dörfel, head of the Plastics Laboratory, and his deputy, Dr. Echell, made arrangements not only for me to talk at length with the staff but to give the lecture that had been scheduled for the next day. The attendance at the lecture was quite good despite the last minute rearrangments.

Research in the Plastics Laboratory is divided into work on polyolefins, polystyrene (PS) and polyvinyl chloride (PVC), special polymer systems, coatings and dispersions. There is great amount of cooperative work with other BASF laboratories, especially by the measurement and testing group. Dr. H. Breuer and his associates, J. Stabenow and F. Haaf, have been determining the micromechanics of the fracture of rubber-modified thermoplastics. The rubber is dispersed in the thermoplastic matrix as particles ranging from a few tenths of a micron up to hundreds of microns. The presence of the rubber phase results in a significant increase in toughness over the unmodified matrix (*ESN* 33-1:14 [1979]). The increase in toughness is a result of micro deformations induced at the interface between the matrix and the particles. As shown in the figure,



Stresses at inclusion/matrix boundary
σ_1, σ_2, σ_3, ≡ Triaxial stresses
σ_a ≡ external uniaxial stress

an externally applied stress induces a triaxial stress state in the matrix at the interface. In Breuer's opinion, none of the existing criteria for bulk matrix crazing are adequate to predict the onset of crazes at the interface. Consequently, they have done an extensive microscopy and light-scattering study of the failure of rubber-toughened PVC, PS and a styrene-acrylonitrile copolymer. Among their findings is the fact that crazing is not the only failure mechanism and, indeed, may not be involved at all in some instances. Instead, cavitation and rupture of the particle occurs. Light-scattering experiments reveal that cavitation occurs predominantly in shear bands. Breuer explained this observation by the fact that in a growing shear band the octahedral shear stress component of the stress concentration relaxes, but the hydrostatic component does not relax. The result is that local matrix elongation is accompanied by a local decrease in cross section, i.e., particle rupture. The hydrostatic stress component may also induce matrix cracking but this depends upon the matrix material, inter-particle distance, particle

size, and strain rate. One implication of these results is that light scattering tests of strained, rubber-toughened thermoplastics to determine the extent of crazing can be very misleading since much of the scattering may be due to void formation in the particles.

Dr. W. Retting is well known for his research on the viscoelastic and plastic behaviors of solid polymers. Over the past decade he has worked on the thorny question of how molecular relaxations observed in the range of small deformations, e.g., vibration damping experiments, relate to behavior in the nonlinear range, e.g., tensile rupture or brittle fracture. The relationship is deceptively simple; those relaxations which are effective have time scales equal to or less than the yield time of the nonlinear deformation. However, it has been difficult to establish this idea quantitatively due to the lack of yield data over a wide enough range of time (or temperature) to compare with relaxation spectrum data. In terms of plastic technology, this failure to recognize the time and rate dependence of the mechanical properties of solid polymers has led to disastrous and embarrassing design errors.

Another part of Retting's work has been on molecular orientation in multiaxial, hot-stretched amorphous polymer films. Starting from the fact that there is a definite relationship between molecular orientation and molecular properties, independent of the stretching conditions, Retting has attempted to determine whether mechanical properties related to orientation can be predicted from thermochemical properties. It might be expected that the film would behave as an ideal rubber. Actually, Retting has found that the true stress, σ, and the birefringence parameter, Δn, increase more slowly than would be predicted by rubber theory. Also, σ and Δn are not independent of strain rate or temperature—again in contrast to rubber theory. What he has found is that σ and Δn follow the theory of linear viscoelasticity which strongly suggests the mechanical properties can be predicted for any thermomechanical history using linear viscoelastic formalism. Retting finds this is indeed the case for PS, high-impact polystyrene, PVC and polymethylmethacrylate.

Dr. A. Zoscel, in the Measurement and Testing Laboratory, has done extensive work on organic coatings. Recognizing a time-temperature dependence of the mechanical properties of the polymers used in paints and other coatings, he has measured the viscoelastic properites of coating films during formation and curing and in the cured state—mostly as free film. Zoscel has also attempted to relate the properties commonly measured for films on substrates, such as hardness and impact resistance, to the viscoelastic characteristics of the free film. Sometimes correlations are clear cut but more often they are not. The differences are usually due to film/substrate interactions or to differences in the cure conditions for a coating compared to the same polymer formulation cured as a free film. One of the principal tests Zoscel uses is indentation testing. Using spherical indenters he is able to determine the creep characteristics of a coating on a substrate. He has had some success in relating this identation creep to the tensile creep of the free film.

The micromechanical deformation mechanisms of short glass-fiber-reinforced thermoplastics is the subject of studies by Dr. L. Ramsteiner, also in the Measuring and Testing Laboratory. He has analyzed the tensile failure of composites in which the fibers are oriented in the direction of applied tensile stress, and in which, additionally, all the fiber lengths are below the critical size for fiber fracture. Using the analysis of Prof. A. Kelly (Univ. of Bristol, UK, *Proc. Royal Soc.*, 282A 63 [1964]), Ramsteiner obtained the fiber/resin interfacial shear strength from the linear relation between tensile strength and fiber volume (fiber volume fractions of 0.02 to 0.15). He was able to show that chemical treatment of the glass or chemical modification of the polymer matrix usually increases the interfacial shear strength—usually to a value comparable with the shear strength of the matrix itself. The following are two interesting observations of this work: (1) the matrix adheres to the fiber only when the interfacial-shear strength is comparable to the matrix-shear strength, and (2), the loss in impact strength by introduction of the fiber is minimized when the magnitudes of the interfacial shear strength and the matrix shear strength are comparable. Ramsteiner also found that in some instances the measured interfacial-shear strength exceeds the matrix strength. The differences were not large and could reflect uncertainties in the data analysis. On the other hand, it is possible that the molecular structure of the polymer

in the interfacial region differs from the matrix or that the interfacial-stress condition is different from that assumed in the Kelly analysis.

My visit to BASF was interesting and productive. Much of the rubber-toughened plastics work taking place there was of special interest to me, and I found the discussions quite useful. I was impressed with the quality of the fundamental research on polymers at Ludwigshafen but I was equally impressed by the good mix of fundamental and applied work. (Willard D. Bascom, Hercules Inc., Magna, UT)

MATHEMATICS

FOURTH OBERWOLFACH CONFERENCE ON SCATTERING THEORY: SCATTERING PROBLEMS OF CLASSICAL AND APPLIED PHYSICS

The Fourth Oberwolfach Conference on Scattering Theory was held at the Mathematical Research Institute, Oberwolfach, FRG, from 4 to 8 August, 1980. The conference organizers were Prof. P. Werner (Univ. of Stuttgart), and Prof. C.H. Wilcox (Univ. of Utah); at the time of the conference, Wilcox was spending a sabbatical year at the University of Bonn. The institute is located in the area of the German Alps north and east of Freiburg in Breisgau. It is host to mathematics conferences 50 weeks of the year. The conferences and institute are subsidized by the Volkswagen Foundation.

The three previous conferences on scattering theory held at the Oberwolfach Institute took place in 1971, 1974, and 1977, and were devoted primarily to quantum-mechanical scattering theory. By contrast, the 1980 conference was entitled "Scattering Problems of Classical and Applied Physics," although a number of talks on quantum-mechanical scattering were also given.

About 30 scientists from Austria, Denmark, France, FRG, Japan, the UK, the US, and Yugoslavia participated in the conference. The countries with the most representatives attending were FRG, the US, and Japan, in that order. Some of the most distinguished names in scattering theory were present. The majority of the participants were mathematicians affliated with academic institutions, but there was also a small number of physicists. The nonacademic institutions represented at the conference were Bell Laboratories and the US Naval Research Laboratory. There were 21 speakers who presented 23 talks embracing a very wide range of topics in classical and quantum-mechanical scattering theory, and in inverse scattering theory. The subjects discussed ranged from an inverse problem in linear transport theory to the completeness of long-range modified-wave operators, and from scattering theory for linear thermoelasticity to coherent scattering from rough surfaces. Prof. S.T. Ikebe, T. Kato (Univ. of Calif., Berkeley), S.T. Kuroda (Univ. of Tokyo, Japan), R. Leis (Univ. of Bonn, FRG), E. Meister (Tech. Univ. of Darmstadt, FRG), P. Werner, and C.H. Wilcox chaired conference sessions.

As in the past, the 1980 Oberwolfach Conference was leisurely and unhurried; about 50 minutes were allotted to each lecturer, and some 6-8 papers were delivered each day. In keeping with the tradition of Oberwalfach conferences, no formal proceedings were published.

Prof. Wilcox opened the conference on the morning of 4 August, mentioning that papers on classical scattering and allied topics would be the most numerous, and asking each speaker to write an abstract of his talk for inclusion in a special book kept at the Mathematical Institute. This is also a tradition at the Oberwolfach conferences, whether devoted to pure mathematics or to its applications.

Quite appropriately, the first lecture was delivered by Prof. R.S. Phillips, an eminent functional analyst and the codiscoverer of the Lax-Phillips method of scattering theory. A disadvantage of this method has been its inability to deal with perturbations extending over unbounded domains, such as occur in acoustic scattering by inhomogeneities of nonbounded support. In his talk, entitled "Scattering Theory for the Wave Equation with a Medium Range Perturbation," Phillips presented an extension of the Lax-Phillips method to the wave equation, $u_{tt} = \partial(a_{ij}\,\partial_j u) - qu$, when $q = O(|x|^{-\alpha})$, for $\alpha>2$ and $a_{ij} - \delta_{ij} = O(|x|^{-\beta} = \partial_{ij}a_{ij}$, for $\beta>1$; for odd-dimensional spaces. He mentioned that although the results obtained were well-known consequences of the usual time-dependent scattering theory, his adaptation of an argument of V. Enss to hyperbolic systems made the elucidation simpler and more straightforward than earlier arguments.

In the summary of the discussions which follows, the presentations are

grouped broadly into the three following categories: Classical Scattering Theory, Quantum-Mechanical Scattering, and Inverse Scattering. For the most part, they are not treated in chronological order.

Classical Scattering Theory

An application of the Lax-Phillips method to calculate the amplitude of acoustic waves scattered by moving obstacles was presented by Prof. J. Cooper (Univ. of Maryland). The work was done jointly with Prof. W.A. Strauss (Brown Univ.). When the obstacle is moving, the reflection of a plane wave of frequency ω no longer has a single frequency, but, instead, the scattering amplitude is a distribution in ω and the frequencies ω', of the scattered waves. If $(\omega'-\omega)$ is real, a holomorphic extension can be constructed for $\mathrm{Im}(\omega)<0$. If the motion is periodic with frequency ν, a meromorphic extension of the scattering amplitude exists for $\mathrm{Im}(\omega)>0$, which can be expressed as a sum of partial amplitudes at frequencies, $\omega' = \omega + m\nu$, m being an integer.

Prof. A. Ramm (Univ. of Michigan), spoke on two topics: "Non-Self-Adjoint Operators in Diffraction and Scattering," and "Wave Scattering by Small Bodies of Arbitrary Shape." The second was particularly interesting from the standpoint of applications to electromagnetic scattering problems. Diffraction and scattering problems can be formulated as integral equations of the form $A\sigma = f$, where f is known, σ unknown, and the known operator A is non-self-adjoint. A method of solution going back to F. Riesz is based on the root system of A and, using this, a Jordan chain of equations can be constructed as partial solutions. Ramm discussed the conditions under which the root system of a non-self-adjoint operator forms the basis of a Hilbert space. He also discussed the singularity-expansion method whereby one can determine the complex poles of the Green's function of a problem directly from the impulse response of a detector. The method is analogous to the resonance theory methods discussed by Prof. H. Überall (see below). In this second paper, Ramm also presented some extensions of the classical perturbation approach of small-body scattering to multibody systems.

Scattering by rough surfaces was discussed by three consecutive speakers. The first was Dr. J.A. DeSanto (US Naval Research Lab.), whose talk on "Coherent Scattering from Rough Surfaces" presented a mathematical formalism for calculating the scattering in question by means of Feynman diagrams. For an arbitrary deterministic rough surface, DeSanto has previously shown that the scattered part of the Green's function obeys a Lippmann-Schwinger type of integral equation, analogous to the equation formulated for quantum-mechanical scattering. Here, however, the corresponding "potential" is noncentral and complex. For a random surface with homogeneous statistics, the ensemble average of the scattered Green's function obeys a one-dimensional singular integral equation, an approximation to which has been solved numerically for a gaussian-distributed surface and plane-wave incidence. His results strongly suggest that multiple-scattering effects must be taken into account to obtain agreement with experiments for very rough surfaces.

Next, Dr. A.W. Sáenz (US Naval Research Lab.), spoke on "Asymptotic Completeness for Scattering from Periodic Surfaces with the Homogeneous Dirichlet Condition." This work was motivated by a model for the quantum-mechanical scattering of low-energy atoms by crystal surfaces, but the methods also apply to classical scattering. He presented two main results which involve no assumptions on smoothness about the periodic surfaces in question. One result was that the range of the relevant wave operators, with $-\Delta$ in $L^2(\mathbb{R}^n)$, and $n>2$, as the unperturbed Hamiltonian and with the negative Dirichlet Laplacian in the external domain Ω of interest as the perturbed Hamiltonian, were equal to the subspace of scattering states. The other result was that these wave operators were asymptotically complete, in the sense that the space $L^2(\Omega)$ is the direct sum of the latter subspace and the subspace of surface states (in the sense of Davies and Simon). Ideas of L.C. Lyford are used in this work, which Sáenz has extended to the case of the homogeneous Neumann condition.

The third presentation on rough surfaces, by C.H. Wilcox, mentioned earlier, was entitled "Scattering Theory for Diffraction Gratings." Wilcox treated the cases of the homogeneous Dirichlet and Neumann conditions. The profound mathematical results he discussed were partially based on his generalization of work of H.-D. Alber, now at the University of Bonn. Again, with no assumptions of regularity or smoothness on the grating surface for the Dirichlet case, and with certain assumptions of smoothness in the Neumann case,

Wilcox obtained eigenfunction expansions of the scattered wave field in terms of Rayleigh-Bloch waves, a subject discussed by him in two (1980) reports published recently from the University of Bonn. As a by-product of these latter results, he has been able to show that the respective spectra of the Dirichlet and Neumann Laplacian, for the two-dimensional grating domains considered, are purely absolutely continuous. In his talk, Wilson also announced results concerning the existence and completeness for the relevant wave operators under the hypothesis that no surface waves exist. Here the perturbed case is the grating domain of interest and the unperturbed case is a suitable half-space.

Prof. T.S. Angell (Univ. of Delaware), spoke on "Scattering Control for the Robin problem." His approach was to use a boundary integral equation formulation for the exterior Robin problem for the Helmoholtz equation. The method generalizes previous work on the Dirichlet and Neumann problems. The cost functional for the problem is the power in an angular sector of the far field, and the control is that of maximizing this functional over a set of admissible Robin (or impedance) boundary data.

Prof. M. El Mabrouk (Univ. of Villeneuve d'Ascq, Lille, France), spoke on "Scattering Theory for Linear Thermoelasticity." He treated the solution of a system of differential equations coupling the elastic displacement with thermal gradients. The system is dissipative, and one desires to know the asymptotic behavior of these thermoelastic waves scattered by a bounded obstacle with the homogeneous Dirichlet boundary condition. The methods generalize the Lax-Phillips theory for the corresponding nondissipative systems.

Prof. H. Tamura (Univ. of Nagoya, Japan), discoursed on "The Principle of Limiting Absorption for Propagative Systems in Crystal Optics with Perturbation of Long-Range Class." For an appropriate long-range perturbation of Maxwell's equations describing crystal optics, Tamura has proved a limiting absorption principle in a suitable weighted L^2 space. The equations considered in his work constitute an example of a nonuniformly propagative system.

In a presentation entitled, "Scattering Theory for Matrix Operators and the Indefinite Inves Product," Prof. B. Najman (Univ. of Zagreb, Yugoslavia) discussed the spectral and scattering theory for abstract second-order differential equations of the form, $\frac{d^2u(t)}{dt^2} - iK\frac{du(t)}{dt} + Hu(t) = 0$, in a Hilbert space, with suitable operators H and K. This equation can be considered a perturbation of the Klein-Gordon equation, and hence, the results of this work can be regarded as generalizations of the spectral and scattering results for this equation.

Prof. H. Überall (Catholic Univ. of America) gave two talks summarizing work done with his collaborators. In the first, "Resonanace Theory of Nuclear, Acoustic, Elastic, and Electromagnetic Scattering," he discussed how methods of nuclear-resonance theory were applied to interpret acoustic scattering by elastic bodies, elastic waves by cavities and inclusions, and electromagnetic waves by dielectric and conducting targets. He pointed out that resonances provide information on the properties of the target, i.e., they help in solving the inverse problem. In all the cases considered, including resonances in electron and heavy-ion reactions, the origin of the resonances was traced back to the phase-matching of surface waves generated by the scattering. Überall's second talk, "Theory of Mode Coupling and Sound Propagation Under the Ocean," dealt with the propagation of scalar fields in laterally nonuniform ducts and with the application of the theory to acoustic propagation in under-ocean sound channels. The adiabatic mode theory of Pierce and Milder, which also furnishes mode-coupling terms, was used in the calculations. Several examples were considered, both adiabatically and with mode coupling included. The same approach was used by Überall and his collaborators for treating coupled-wave propagation in the ionospheric day-night transition region.

Quantum-Mechanical Scattering

Dr. D.B. Pearson (Univ. of Hull, UK), the second speaker at the conference, discussed "Localization of States in Position and Energy." The results apply to a Hamiltonian H which is a self-adjoint extension of $-\Delta + V(x)$ on $C_0^\infty(\mathbb{R} \neq \{0\})$, where $V(x) \to 0$ as $|x| \to \infty$ and may be singular at $x = 0$. The degree to which states are localized in the ball $B(R) = \{|x| < R\}$, and in the interval Δ of the spectrum of H is respectively "measured" by the limits:

$$\mu(\Delta) = \lim_{R \to 0} \| \chi_{B(R)}(x)\, \chi_{\Delta}(H) \|$$

$$\mu'(\lambda) = \lim_{\substack{\varepsilon \to 0 \\ R \to 0}} \| \chi_{B(R)}(x)\, \chi_{(\lambda-\varepsilon, \lambda+\varepsilon)}(H) \|,$$

where χ_A denotes the characteristic function of set A. Pearson has shown, under the above assumptions, that either $\mu'(\lambda) = 1$ ("singular point") or $\mu'(\lambda) = 0$ ("regular point") for each real λ, and that $\mu(\lambda) = 0$ or 1 unless the endpoints of A are singular points. He gave a complete list of the phenomena which give rise to singular points, including the breakdown of asymptotic completeness, nonempty singular continuous spectrum, and discontinuity of the scattering amplitude at given energy.

Prof. T. Ikebe (Univ. of Kyoto, Japan), talked on "A Stationary Approach to the Completeness of the Long-Wave Modified Wave Operators." After reviewing various approaches to long-range potential scattering in quantum mechanics by himself, Prof. V. Enss, and others (Ikebe, Isozaki), he sketched a proof of the completeness of the relevant wave operators by a stationary method. His proof involved the formulation and proof of a suitable limiting absorption principle in a weighted L^2 space.

Prof. Enss (Univ. of Bochum, FRG) spoke on "Finite Total Cross-Sections in Quantum Mechanics." Using his celebrated time-dependent geometric approach, he was able to determine simple explicit upper bounds on total cross-sections, σ_{tot}. For sperically symmetric potentials, upper bounds on σ_{tot} were proved by him for large values of the coupling constant. In a multiparticle system where the particles interact by Coulomb potentials, he has shown (jointly with B. Simon) that the total cross section for atom-atom scattering is finite.

"Some Remarks on Enss' Method in Quantum-Mechanical Scattering Theory" was presented by Dr. R. Colgen (Univ. of Frankfurt/Main, FRG). Using this method and its generalization by Simon, he proved a result in abstract scattering theory which gives sufficient conditions for the strong asymptotic completeness of the relevant wave operator.

Dr. A. Jensen (Univ. of Aarhus, Denmark), presented several new rigorous results on "Time-Delay in (Quantum-Mechanical) Scattering Theory" for Hamiltonians $H = -\Delta + V$ in $L^2(\mathbb{R}^n)$, with V real-valued, locally square-integrable, and behaving as $O(|x|^{-\beta})$ at infinity for some $\beta>2$. Under these assumptions, he was able to prove that the Eisenbud-Wigner time-delay operator T exists, is essentially self-adjoint, and commutes with H. The operator T has "diagonal" matrix elements given by a familiar expression representing differences in time spent in a ball of radius R for the free evolution and for the evolution under H, in the limit $R\to\infty$. The validity of this expression was proved by Jensen for a dense set of Hilbert space vectors when $\beta>4$.

In a talk entitled "Time-Dependent Perturbations in Scattering Theory," Prof. H. Sohr, (Univ. of Paderborn, FRG) stated an abstract lemma on the subject, recently proved by him, and discussed some of its applications, such as existence proofs of solutions of certain linear and nonlinear evolution equations. He also announced an asymptotic completeness result for quantum-mechanical time-dependent scattering.

Prof. C.G. Simader (Univ. of Bayreuth, FRG) reported on recent work (done with H. Leinfelder) on "Essential Self-Adjointness of Schrödinger Operators with Magnetic Vector Potentials." This work improves previous results on the topic due to T. Kato (1978) and B. Simon (1980). Essential self-adjointness of the operators in question is proved by showing that, for suitable classes of scalar and vector potentials, the maximal and minimal forms of the corresponding formal expressions coincide.

Inverse Scattering

"Exotic Topics in Inversion Theory" were discussed by Prof. P. Sabatier (Univ. of Languedoc, Montpellier, France). He described some exact inversion methods related to geophysical problems, simple ways of appraising the manner in which the pertinent problems were posed, and ways to obtain constructive methods for approximate solutions. "Exotic" refers to problems which violate some of the above approaches. Some examples were given and quasi-solutions of the examples were discussed. One problem of interest was that of water waves produced by ground motion. Here the ground motions are measured and the reconstructed object is the water-wave amplitude. Other problems briefly mentioned by Sabatier were spectral problems (given the eigenvalues, find the spectral measure) analogous to the problem of the beam discussed by Prof. Barcilon (see below), extension of Gel'fand Levitan methods, and problems involving nonlinear equations of evolution.

Prof. V. Barcilon (Univ. of Chicago) chose "Inverse Sturm-Liouville-Like Problems" for the topic of his lecture, in which he discussed spectral problems motivated by the geophysical problem of determining the internal structure of the earth from its natural frequencies. These problems involve systems of ordinary differential equations of

fourth order or higher. A pertinent example is the equation describing a vibrating beam. Barcilon surveyed the present knowledge on these problems including questions of existence, uniqueness, and construction of solutions.

Prof. Y. Saito (Univ. of Osaka, Japan) discussed the "Inverse Scattering Problem for Short-Range Potentials." He investigated the scattering amplitude for the three-dimensional Schrödinger Hamiltonian with such a potential by means of a spectral approach due to Ikebe. Saito has shown that the solution of the inverse scattering problem is unique under the assumed conditions.

Dr. W.W. Zachary (US Naval Research Lab.), spoke on the "Discrete Spectrum of Schrödinger Operators for a Sum of Potentials: Connection with the Inverse Scattering Formulation of Nonlinear Evolution Equation." The work he discussed mainly concerns the spectral theory of Schrödinger operators when the potential is the form U = V + Q, where V is periodic and Q decreases rapidly at infinity. This work is motivated by developments in the theory of the Korteweg-de Vries equation, where solutions are known for potentials which correspond to V and Q, but none are known that correspond to U. The following results were discussed: (1) estimates of eigenvalues when V is periodic and Q = 0; (2) asymptotic distribution of eigenvalues for V periodic and Q rapidly decreasing; (3) upper bounds on the number of negative energy eigenvalues for V bounded from below and $Q \in L^{n/2}(\mathbb{R}^n)$, $n \geq 3$; (4) exponential decay of negative energy eigenfunctions for V bounded from below and Q in suitable L^p classes.

Two lectures on theoretical tomography were presented at the conference. The first, on "The Problem of Reconstructing Density Functions from Projections as an Inverse Problem in the Scattering Theory of the Linear Transport Equation" was given by Prof. J. Hejtmanek (Univ. of Vienna, Austria). His lecture dealt with some mathematical aspects of computerized tomography (CT). The equation describing the time evolution of the photon density in phase space for the CT model is a special case of the neutron transport equation for which scattering theory results have previously been developed by Hejtmanek and others. For the CT model, it was shown that the scattering operator is a multiplication operator involving the Rontgen transformation and that it is a one-to-one mapping of the position cone $L^1_+(\mathbb{R}^2 \times S^1)$ onto itself. The inverse problem is solvable by means of the inverse Radon transformation.

The second talk on tomography was given by Prof. F. Stenger (Univ. of Utah) who discussed "Ultrasonic Reconstruction Tomography." This work is based on a numerical inversion of the Helmholtz equation by the method of splines. Plans are underway for the construction of a machine at the University of Utah to perform such calculations.

"Inverse Scattering Applied to Problems in Speech and Hearing" was the topic of the presentation given by Dr. M.M. Sondhi (Bell Labs.). In his research, he applied one-dimensional inverse scattering theory to the inference of properties of idealized models of the vocal tract and of the inner ear. He presented new experimental results on these questions. The theory used has been summarized by him in the *Proceedings of the Conference on Mathematical Methods and Applications of Scattering Theory*, May 1979, Washington, DC.

As a concluding note, it might be observed that the wide variety of topics that were competently presented, and the opportunity to communicate with a number of scientists who are recognized authorities in their fields, combined to make the conference interesting, informative, and productive. (J.A. DeSanto, A.W. Saenz, and W.W. Zachary, Naval Research Laboratory, Washington, DC 20375)

OCEAN SCIENCES

THE INSTITUTE FOR MARINE SCIENCES AT THE UNIVERSITY OF KIEL, FRG

The marine research program at the University of Kiel dates back to about 1870, when biologists there began to study the ecology of the Kiel Bight, and to investigate marine plankton. The marine research program grew slowly until the turn of the century, when the Prussian Commission for the Scientific Exploration of the Seas Around Germany created a "laboratory for internal marine research" in Kiel. This laboratory, with programs in physical, chemical, and biological oceanography, had one of the first comprehensive marine science programs in the world.

Following World War I, Berlin became the center for marine research in Germany with the Institute for Marine Science at the University of Berlin, and it was not until 1936 that

marine research in Kiel regained its earlier importance. In 1937, the Institut für Meereskunde (Institute for Marine Sciences) was founded with programs in biological, chemical, and geological oceanography. In July 1944, the institute building on the east bank of the Kiel Fjord was totally destroyed by bombing. Nine members of the senior staff, including the director, Herman Wattenberg, lost their lives.

After World War II, the institute moved to the west side of the fjord in the city of Kiel. It grew very rapidly in the next two decades. By 1970, the institute's staff members were housed in 10 different locations in the city. About this time the city gave the institute a beautiful building site in a park-like promenade, right on the fjord near the city center. The city stipulated that in exchange for the site, the institute must maintain a large public aquarium. A magnificent large, 7-story building was completed in 1972; the new construction included a harbor for the institute's research vessels. This harbor is located right in front of the main building. With a staff of 250 people, including over 100 scientists, the building is now crowded and it is hoped that a new wing will be added in the near future.

The directorship of the institute is usually rotated every 2 years. The present director, Prof. B. Zeitzschel, is also head of the Marine Planktology Department. The institute is supported about equally by the state of Schleswig-Holstein and the Federal Ministry of Education and Science. Additional funds are obtained in support of special projects from the Deutsche Forschungsgemeinschaft (similar to the US National Science Foundation).

The institute operates four research vessels, which have been built within the past 15 years. These, and their usual scientific complements are: *Poseidon*, 60 m long, 12 scientists; *Meteor*, 30.8 m long, 12 scientists; *Littorina*, 20.5 m long, 6 scientists; and a launch, *Capitän*, 11 m long, 3 scientists. These research vessels are also used by scientists from other laboratories, in somewhat the same manner as the University National Oceanographic Laboratory System (UNOLS) of the National Science Foundation operates in the United States. Members of the institute also use the large governmental research ships *Meteor* and *Planet* for long-distance cruises.

It should be noted that while the institute uses the university as part of its offical title, it is at but is not part of the university. Institute staff members who teach classes have joint appointments with the institute and the university. About 50 formal lecture courses are offered each year at the institute. These cover a wide range of subject matter in marine science. University students who major in marine science begin their university work at the age of 19 or 20. They study for about 4-5 years to receive their diploma, which is considered a little more advanced than the MA or MS degree in the United States. They also have to pass a vordiplom (prediploma) examination after 4-5 semesters (2 years), but they would not be able to find a technical job in marine science if they left at this stage. Students who continue at the Institute after the diploma usually work full time and do thesis research for the PhD degree. The institute normally has about 50 PhD candidates in residence. Contrary to American practice, these students are not normally supported by research and teaching assistantships.

A good deal of marine research and instruction is also carried out in other departments of the university that are not part of the institute. For example, there is a major effort in marine geology in the Geologisch-Paläontologishches Institut und Museum, and the Physikalisches Institut has a marine geophysics program and a marine optics program. However, only the programs in the Institut für Meereskunde are mentioned further in this report.

There are three Departments of Physical and Chemical Oceanography: Regional, Theoretical, and Marine Physics. Research in the Regional Oceanography Department is concentrated on three subjects. The first is the study of transport processes in the North Atlantic Ocean. Here, among the questions asked are: What are the effects of the Mid-Atlantic Ridge on the North Atlantic current when the current passes over the ridge? What are the mechanisms involved in the movement of Norwegian Seawater overflow across the Iceland-Faroe Ridge through the Faroe-Shetland channel? How does deep water spread within the Norwegian Sea?

The second project in the Regional Oceanography Department is concerned with mesoscale oceanic fronts. At issue is how these fronts are related to eddies, with special reference to the cascade of kinetic energy from big eddies or gyres to small-scale turbulence.

A third study effort is directed to convection processes in oceanic surface layers. The principal objective

is to parameterize convection for inclusion in ocean circulation models.

The Department of Theoretical (physical) Oceanography is primarily involved in ocean modeling and in developing statistical techniques for handling large sets of data in models. A considerable amount of the present work is aimed at the understanding of large-scale ocean circulation and fluctuations in heat transport, with the goal of determining the relative importance of meanders and eddy motions on large-scale heat transfer. The area of interest is the North Atlantic, from the Canary Islands to Iceland. Interannual variance in climate over northern Europe is quite large; many European oceanographers believe that these changes are directly related to interannual changes in heat transport in the North Atlantic. An extremely large data base from many hydrographic stations in the North Atlantic is being utilized in this effort to relate oceanic and climatic variances. Another project of the Department of Theoretical Oceanography involves the employment of satellite infrared imagery to study water surface temperatures in the North Atlantic. Of primary interest here are structures that persist for periods of several weeks.

The Marine Physics Department's research program is concentrated in two fields: the investigation of physical processes in the oceans by means of experimental observations, and the development of new measurement techniques and instruments. All of the work on new instruments is fully integrated: the department takes it all the way from conception, to design, construction, and field testing. Marine Physics is also responsible for all mooring activites in the Institute. The latest major new instrument is a free-fall multisounder that rapidly measures salinity, temperature, and depth. In addition to the normal STD sensors, a rapid-sampling acoustic current meter has been added. This instrument has been under development for 2 years. It has now been tested and debugged, and will be operating in the Canary Basin this year.

The physical processes under investigation include the mixing and fine structure of water masses, internal motion in the ocean, and processes in near-surface and bottom-boundary layers. Experimental investigations of mixing and transport processes in the Baltic Sea are used for modeling and predicting the distribution of marine pollutants. Also from the Baltic, bottom boundary-layer observations are employed in the study of erosion and the movements of bottom sediments. Considerable work has been done on the theory, observation, and generation of internal waves in the Atlantic Ocean.

A theoretical group is modeling atmospheric forcing of mesoscale variability in the ocean, and is carrying out field work to test and improve the model. The department has just completed a 4-year current-meter and thermistor-chain study of the North Atlantic area bounded by 33° - 52° N Lat. and 10° - 25° W Long. Some of the time series run for 2 years, and many are at least 1 year long.

Almost all members of the three Departments of Physical and Chemical Oceanography, along with technical people from the Department of Maritime Meteorology, plan to take part in the North Atlantic project "Warm Wassersphere," which started in 1980 and should last about a decade. This project has been planned in detail and funded through 1983. The components and techniques of the program resemble some of those which have already been described. The major differences are that many more people will be working on the project than on previous ones, and that the field-sampling program will be highly concentrated, with closely spaced observations. A series of 250-km-square "boxes" have been designated in the area between the Canary Islands and 60° N Lat. Each box will yield data on the heat flow of the lens of near-surface water above the 8° - 10° isotherm; it is this lens of water that moves the heat poleward and that has the greatest variability. The research goals are to explicate further the mechanisms involved in heat transfer and to construct more accurate and, in some cases, high-resolution models of oceanic heat transfer.

The Department of Marine Chemistry has 12 senior staff members. The department's main field of study is the chemistry of the Baltic Sea. This sea, because of its restricted outlet to the North Sea, its large fresh-water runoff, and its excess of precipitation over evaporation, is virtually a brackish lake. These conditions cause a poverty of marine life due to low salinity; and since the remaining marine animals are already stressed by the low salinity, pollution renders the animal population even more vulnerable. The Kiel chemistry group is collaborating with marine chemists from other countries around the Baltic Sea in keeping the sea as clean and as free from pollution as possible. A regular research cruise in the Baltic

each year is dedicated to the measurement of both organic and inorganic pollutants.

Other ongoing studies include: chemical processes and reactions at the interface between the ocean water and bottom, the distribution of trace metals in the ocean, the atmospheric fallout of metals into the ocean, the carbon dioxide cycle between the ocean and atmosphere, the lipophylic organic constituents of seawater, and the effects of petroleum products that may interfere with hormone activities in marine organisms. Faculty members told me that foreign marine chemists are welcome to go on chemical cruises, provided that they pay their own travel expenses.

The Department of Maritime Meteorology is under the direction of the well-known air-sea-interaction specialist, Dr. L. Hasse, formerly at the Meterological Institute at the University of Hamburg. Hasse has been in Kiel less than a year. The department plans to add a second professor who will be a specialist in remote sensing in meteorology and oceanography. Most of Hasse's research has been on the physics of the planetary-boundary layer over the ocean, and the exchange between the atmosphere and the ocean at the air-sea interface. At present, he is helping to plan a joint British-German experiment in the North Sea for September and October 1981. This venture will obtain data for developing models of the planetary-boundary layer over the ocean; it will also determine whether boundary-layer models for conditions over land can be used over the sea, provided the proper boundary conditions are taken into account. In this sizable project, between five and seven radiosonde stations will be in operation from islands and ships, and observations will also be taken from aircraft. The idea is to obtain a relatively complete picture of divergence, convergence, turbulence and advection throughout a rectangular volume of the planetary-boundary layer over the sea.

The Department of Marine Botany is undergoing major changes. The new head is a benthologist, and the department may be renamed the Benthic Studies Department. In the past, the department has collaborated with other laboratories on phytobenthology in the Baltic; the work was sponsored by Sonderforschungsprogramm No. 96 and by the Baltic Research Project of the Baltic Marine Biologists. The research was interdisciplinary, with special emphasis on productivity of the phytobenthos; observations were made by means of diving and underwater television, with [illegible] measurements of the O_2 budget by means of the plastic bag method. There were also numerous laboratory studies. According to present plans, zoologists will be added to the staff, and the main theme of the department will continue to be the overall study of benthic biological communities.

The chairman of the Department of Marine Zoology is carrying out a project concerned with the biochemistry, physiology, hormonal activity, molting process, and growth of crabs. The overall objective is to solve the basic problems, including development of an optimal diet related to the commercial aquaculture of crabs. The group has been successful in the spawning and raising of two generations of a common local species of crab.

An associated group is studying the growth and development of other species of crustaceans, including Antarctic krill. They are also studying the chemicals excreted by crustaceans as a sex attractant. The only time that many crustaceans can mate is just after molting. The females of some species secrete an attractant just before they molt.

A rare and relatively unstudied group of marine animals called Pogonophora is also under investigation. Although they may be as much as a meter in length, these organisms have no mouth or alimentary canal, and they absorb dissolved materials as their source of food. Their position in the systematics of marine organisms is still open and in question.

Another Marine Zoology project has to do with the effects of stress factors on invertebrates, including worms and mussels. Some of the factors under investigation here are heavy metals, abnormal temperatures, and low dissolved-oxygen content.

The largest department in the Institute is the Department of Fisheries. There is a concentration on the Baltic and North Seas, and on the Antarctic Ocean. Dr. U. Kils is working on the intensive culture of salmon and trout. He now is growing very-high densities of salmon in cages in the Southern Baltic Sea. One of the biggest problems is heavy fouling of the cages. The present cages are half exposed to the air, and are rotated every 2 weeks. The larvae of fouling organisms that have settled on the submerged part of the cage during the 2-week period are thus exposed to the air for 2 weeks. The high density of fish in the cages necessitates aeration. All the by-

products are being collected to help determine the efficiency of the feeding systems.

In one project, an endeavor is being made to find new species of marine organisms that are suitable for aquaculture. Turbot has been successfully spawned and grown past the difficult stages. Kils is also involved in the development of a closed ecosystem wherein silver carp are grown in the same tanks as the common mussel. Kil's infectious enthusiasm for his aquaculture reminded me of the personnel in the Israeli mariculture center in Elat, Israel (*ESN* 34-12:560), so I was not surprised when he told me that he visited the Elat center frequently and had joint projects underway with the group at Elat. I found out later that he had won a coveted prize from the Ministry of Technology for the most innovative research by a young scientist (under 32). A typical Kils innovation: krill are denser than seawater and must swim all of their lives to stay in the euphotic zone. Kils has determined the amount of energy required.

The department has carried out considerable research in the Antarctic on some Antarctic fishes and krill. They have inventoried the krill, have studied its early life stages, and have done physiological and behavioral studies of krill swarms. At the time of my visit, a number of staff members of the Department of Marine Planktology were in the Antarctic studying all phases of the spring phytoplankton bloom.

Although the Antarctic is a main area of study in the department, the continuation of these studies in Kiel is very much in question. A political decision has been made by the government to concentrate all Arctic and Antarctic studies in a new Polar Research Institute that is to be located in Bremerhaven.

The department also works with the mariculture center in Elat, with the idea of developing better methods for culturing algae; the algae are used as food for larval stages of fish that are raised in aquaculture tanks. One or two cruises are made each month in the Baltic when it is ice-free, to study the standing crops of phytoplankton and zooplankton. This work is done in cooperation with marine chemists, who are carrying out pollution studies in the Baltic.

The Marine Microbiology Department is unusually large, with 11 senior staff members and 5 PhD candidates in residence. The primary aim of the departmental research effort is to delineate the role of bacteria in transforming organic matter from primary producers, especially phytoplankton, to consumers (for example, ciliates and rotifers) in the water column and in bottom sediments. During my visit, some of the staff members of this project were also in the Antarctic, aboard the R/V *Meteor*, where they were working on the size and population of bacteria that were living on exudates from phytoplankton.

The institute in Keil is a most beautiful and pleasant marine laboratory. It is a popular place for American marine scientists to do research during sabbatical leaves, and it is certainly recommended for that purpose. All the research people that I met spoke excellent English. It is not a resort in midwinter, because frequent storms bring bitterly cold weather. The three visits I have made there in summertime, however, have been most delightful. (Wayne V. Burt Oregon State University)

PHYSICS

A VISIT TO THE UNIVERSITY COLLEGE OF NORTH WALES, BANGOR

The University of Wales has many campuses and, taken as a whole, is one of the larger universities in Britain. That part situated in Bangor, the University College of North Wales, is relatively small (3,000 students). The School of Physical and Molecular Science, an administrative unit formed in 1972 by an amalgamation of the Physics and Chemistry Departments, has a faculty of 22 (8 physicists and 14 chemists) of whom 3 are professors. The school offers single BS degrees in physics, the science of materials, chemical physics, marine chemistry, and marine physics. It also offers joint BS degrees in physics with electronic engineering, materials science, or mathematics; and chemistry with biochemistry, marine biology or soil science. At present, approximately 20 students begin the study of physics every year. Research in the school covers a fairly wide spectrum in physics and chemistry. I visited three groups working in solid-state physics.

Dr. J.C.A. Van der Sluijs came to Bangor to do cryogenic research with Dr. E. Mendoza, who since has left there to go to the Hebrew University in Jerusalem. Van der Sluijs has remained in Bangor and has been concerned with several low-temperature projects; principally, he has been measuring the Kapitza resistance of

metal-liquid helium interfaces. When heat flows across such a boundary of area A, the heat flow, Q, is related to the temperature difference, ΔT, by $\dot{Q} = h_k A \Delta T$; this relation is similar to the standard heat-flow equation for convection. R_k ($R_k^{-1} = h_k$) and h_k are universally known as the Kapitza resistance and conductance, respectively. At low temperatures, the Kapitza resistance can be the dominant term which controls the establishment of thermal equilibrium.

Results are usually compared in terms of α, the mean fraction of phonons transmitted across the boundary. From kinetic theory, it can be shown that $\alpha = 4h_k/vC$ where C is the specific heat capacity and v is an appropriately averaged sound velocity. At sufficiently low temperatures where the Debye approximation holds ($C \sim T^3$), the Kapitza conductance, h_k, is expected to be proportional to T^3, assuming that α and the sound velocity v are independent of temperature. Both the sound velocity and the density vary greatly across the boundary, and the consideration of these facts, in addition to the small acceptance cone in the liquid helium (acoustic impedance theory), leads to a theoretical expression, $\alpha_t = \rho_1 v_1 / \rho_2 v_2$. Ultrasonsic experiments at frequencies up to approximately 1GHz are generally in agreement with this prediction, which is about 0.002 for liquid helium to copper. The results of low-temperature heat transfer experiments (which give α) are generally about 10 to 100 times greater. This discrepancy is often explained as a result of acoustic dispersion, since in the experiments the peak of the phonon distribution in a heat pulse occurs in the 100 GHz range, well beyond the limit of ultrasonic experiments. The general expectation is that, as the mean frequency of the experiments is lowered (by going to lower temperatures), the value α will approach the theoretical limit α_t.

Another possibility is that this scattering of phonons takes place at the surface by reason of impurities or dislocations. This scattering of bulk waves in the solid causes the transfer of energy into evanescent waves, which couple strongly into the liquid. Van der Sluijs and his students have measured the Kapitza conductance of Cu and Ag interfaces with ^{4}He in the 1-2°K temperature range as a function of surface treatment. (*Solid State Comm.* 28 973 [1978]) (*J. Low. Temp. Phys.* 34 215 [1979]) The dislocation density at the surface was varied by hand polishing and subsequently removing a layer of material by electropolishing. For Ag, the results showed a diminution of α from almost 20% to less than 5% as a little more than 150 μm were removed, and an approximate T^3 dependence of h_k.

In addition to these results, the temperature difference observed across the interface was found to vary nonlinearly with the heat flux, $\dot{Q}$. This anomaly was observed over a wider range of temperature difference for Ag (*Solid State Comm.* 32 497 [1979]) than for Cu (*J. Low Temp. Phys.* 33 313 [1978]). The anomaly appears as a sudden increase in slope of ΔT vs $\dot{Q}$ so that the graph is made up of straight line segments. The interpretation of these results is that there exist on the interface small areas, identified with impurity sites, through which most of the heat flows. A second anomaly for Ag was found and was confirmed in later work (*J. Low Temp. Phys.* 39 93 [1980]). The second anomaly is also a sudden change in slope—decreasing to its previous value. This change has been interpreted as occurring at the critical value of heat flux at which the superfluid surface layer transforms into normal helium.

Mrs. Van der Sluijs is a physical chemist who, in addition to raising a family, finds time to work in the laboratory. The husband-and-wife team has a cell for measuring ultrasound velocity and absorption in liquids in the 10-30 MHz range (*Am. Journ. Phys.* 48 278 [1980]). Originally developed as part of an undergraduate laboratory, the cell features a variable path length controlled by a micrometer and can be used for measurements in liquids with relatively high attenuation. Mrs. Van der Sluijs is currently using this apparatus in an investigation of some nematic liquid crystals (cyano-biphenides), using a magnetic field to orient the material. Details of this work are being readied for publication.

Colloidal suspensions of small (40-200Å) single domain particles of Fe_3O_4, Fe, Co, or Ni are called ferromagnetic fluids (or ferrofluids). The particles can be suspended in many different fluids: water, kerosene, dyesters etc., and must be small so as not to agglomerate. The interesting properties are, of course, the magnetic ones which are described by the Langevin theory of paramagnetism, modified to include a distribution of particle sizes. Fluid suspensions have been prepared with saturation magnetization ranging from 50 to 1000 G, with a concomitant range of viscosity from 1 to 10^4 cP.

These materials have found use as rotating shaft seals and recently have been employed in loudspeakers where the ferrofluid serves to center the voice coil and functions as a damper of unwanted resonances. The fluid also cools the coil by conduction, thereby reducing the temperature rise at high input powers. Other uses which have been suggested are: as a linear motion shaft seal, as the fluid part of an inertia damper for motors, as a component of ink for high-speed printers, and as the working fluid in a system or engine which converts heat energy into low-voltage electrical energy.

Ferrofluids have also been suggested as mediums for separation of nonmagnetic materials. Here the principle of operation is that the buoyancy forces on a nonmagnetic material immersed in a ferrofluid can be controlled by an applied magnetic field. It is claimed that materials with densities differing by less than 10% can be separated.

At Bangor, Dr. J. Popplewell and his students have been determining the physical properties of ferrofluids supplied by an American manufacturer. They are primarily interested in the metallic colloids based in toluene, for which they are measuring magnetization curves, magnetic susceptibility, and thermal conductivity as functions of temperature. In addition, a graduate student is working on the preparation of Co ferrofluids from the decomposition of a salt. Popplewell and Dr. S.W. Charles presented a review paper on their research at the IEEE 1981 Intermag meeting in Grenoble.

When a ferrofluid is placed in a magnetic field, optical birefringence is induced. The effect has been measured for Fe_3O_4 particles in several different fluids by Dr. J.P. Llewellyn and his colleague, Dr. H.W. Davies (*J. Phys. D: Appl. Phys.* 12 311 [1979]). The induced birefringence is relatively small, tending toward a saturation value $\sim 90 \times 10^{-8}$ at a field of approximately $\frac{1}{2}$ T. The measurements are useful for determining particle size in solutions much more dilute than those used for susceptibility measurements.

Since the advent of the laser, there has been increased emphasis on the time domain in spectroscopy. (The power spectrum and the autocorrelation function are a Fourier transform pair, and, if the power spectrum has a Lorentzian shape, the autocorrelation function is a simple exponential.) Dr. D. Caroline has developed a program of photon correlation spectroscopy of molecules in solvents in order to obtain information about molecular sizes and diffusion constants. In these experiments, light from an Ar laser (488 nm) is incident on the solution, and the scattered laser line is Doppler shifted as a result of molecular motion. Light scattered at a particular angle is detected by a photomultiplier; the output is fed into a computer which computes a 48-point autocorrelation function for the intensity. By fitting this function with one or more exponentials and some small correction terms, the diffusion constant can be determined from the decay constant of the dominant exponential. Caroline and his students have done considerable work on polystyrene of known molecular weight (*Chem. Phys.* 37 187 [1979] and *Macromolecules* 13 957 [1980]), and he plans to continue these experiments, using various solvents which will allow the molecules to expand and thereby interact.

The school I visited is a small part of a small part of the university. The researchers in the school are active and are well supported by the UK Science Research Council. Those with whom I visited claim that the research productivity per person is greater at Bangor than at some prestigious institutions. It remains to be seen if this support and its resulting research productivity will continue in view of impending budget cuts, directed by the government, which some people fear are focused on the less-well-known institutions. (John R. Neighbours)

FOURTH INTERNATIONAL CONFERENCE ON ELECTROSTATICS

The Fourth International Conference on Electrostatics was held in The Hague, 6-8 May 1981, under the auspices of the European Federation of Chemical Engineering. The conference was organized by the Royal Institution of Engineers in the Netherlands and by the Royal Netherlands Chemical Society. There was international representation: papers came from 13 different countries, and attendees from 19.

Dr. A. Klinkenberg, coauthor (with J.L. van der Minne) of the definitive monograph, "Electrostatics in the Petroleum Industry," was honorary chairman of the conference. In his opening address, Klinkenberg presented a broad philosophical view of the field of electrostatics. In applying Maxwell's equations, he cautioned about the variability of so-called "constants"; the conductivity of hydrocarbon fuels for example, often changes when the fuel becomes charged electrostatically.

Also, a measuring device may change the value of the parameter being measured, as when a field meter in a tank alters the electronic field.

Invited papers were presented by: Dr. S. Masuda (Dept. of Electrical Engineering, Univ. of Tokyo), Dr. J.T. Leonard (Naval Research Lab., Washington DC), Dr. J. van Turnhout (TNO, Toegepast Natuurwetenschappelijk Onderzoek: The Dutch Institute For Applied Research, Delft), and Dr. G. Schön (Physikalisch Technisch Bundesanstalt, Braunsweig).

Masuda discussed industrial applications of electrostatics in pollution control (precipitator and electrostatic augmentation of mechanical dust collection), coal beneficiation, photography (Xerox copying), printing, and painting. Most of these applications result from the ingenious use of Coulombic force which is proportioned to the surface area of the object. Thus, particles, fibers and sheets, all having large specific surfaces, are the objects of applications wherein electrostatic force is used to control their motion. Problems in electrostatic precipitators were discussed, among them the back discharge resulting from high-resistivity coal ash, and the reentrainment of collected dust when the collecting electrodes are rapped.

In his paper, Leonard considered the present status of research on the generation and dissipation of electrostatic charge by hydrocarbon liquids and fuels. Both metallic and nonmetallic fuel handling systems were discussed, as were the special problems encountered in aircraft fuel tanks filled with polyurethane form.

Van Turnhout's review covered photoconduction in solid polymers. In addition, he provided a lecture/demonstration on photoconduction at TNO, which was visited by many attendees.

Schön's subject was the avoidance of ignitions resulting from electrostatic discharges in explosive atomospheres. He defined the risk of explosion as the product of the following quantities:

$$R_{ex} = P_e \times P_i \times P_p$$

where:

P_e = likelihood of occurrence of a potentially explosive atomosphere

P_i = likelihood of ignition of the atmosphere

P_p = the mean extent of damage, given an explosion.

Since, in many applications, P_e and P_p cannot be controlled, means must be taken to reduce the probability of ignition. In practical electrostatic applications, control measures are directed at two probabilites: the probability of generating dangerous levels of charge and the probability of the occurrence of an incinerative discharge. In general, these probabilities are not independent.

Other papers on applications dealt with the use of electrostatic force to emulsify wax (Dr. J.F. Hughes, Univ. of Southampton); a novel form of electrostatic crop sprayer (Dr. I. Inculet, Univ. of Western Ontario); and a new device for the neutralization of pulverulent materials (N. Giboni, Société ECOPOL, Paris).

H. Krämer (Physikalisch-Technische Bundesanstalt) had a paper on electrostatic charging of poorly conducting liquid systems, such as suspensions of silica gel in xylene. These suspensions yield much higher levels of charge when stirred than does the pure solvent.

P.I. Mason (British Petroleum) described the electrostatic hazards resulting from the use of plastic pipes to carry insulating liquids. In addition, there were several papers dealing with the igniting power of discharges from insulator surfaces, and with the hazards associated with highly insulating materials.

Most papers at the conference were poster contributions; among the topics dealt with were electrostatic precipitators and neutralization systems, liquids (hydrocarbons), solids (contact electrification and charging of materials with low charging tendency but high surface resistance), safety (ignition of gases by discharges from plastic surfaces, and spark sensitivity of ignitable gases and powders). The full proceedings of the conference appear in a special issue of the *Journal of Electrostatics*, Volume 10, 1981. (J.T. Leonard, Naval Research Laboratory, Washington, DC)

METAL ORGANIC VAPOR PHASE EPITAXY CONFERENCE REPORT

The first International Conference on Metal Organic Vapor Phase Epitaxy (ICMOVPE) was held 4-6 May, 1981 in Ajaccio, Corsica. It was sponsored by the US Air Force European Office of Aerospace Research and Development and the US Army Research Development and Standardization Group, London, and by five industrial and laboratory organizations.

Over 100 persons attended, and nearly 40 papers, including 8 invited papers, were presented. The affiliations were interesting: of the 22 US attendees,

at least 18 were from industry, while in contrast, participants from other counties were almost equally distributed between industry, university, and government-research groups.

The opening invited paper, by H.M. Manasevit (Rockwell International, US), was a review of Rockwell's work since the development of the first successful MOVPE structures in 1968. Manasevit stressed the importance of high-purity metal organics to the VPE process; he also spoke about the necessity for cooperation between users and suppliers in maintaining the purity of these substances (this theme was repeated throughout the conference). In addition he stressed the need for extremely clean hardware and for the removal of moisture from the material. He predicted that the next challenge would be encountered at the point where the reactants form a liquid phase, and he emphasized that very clever reactor designs would be required at that stage to avoid contaminating the products.

In the session on characterization and physical measurements, G.B. Stringfellow (Univ. of Utah) reviewed his work at Hewlett-Packard Laboratories (Palo Alto, CA) relative to the growth of AlGaAs. He remarked that oxygen contamination was found to be the most serious problem in this process and that some success had been achieved by employing graphite baffles. In this way, lasers have been produced with characteristics comparable to those developed by Liquid-Phase Epitaxy (LPE) and Molecular-Beam Expitaxy (MBE). M. Druminsky et al. (Siemens, FRG) reported on doping GaAs with silicon and finding near-band-gap photoluminescence which was markedly higher than that achieved with Se or Te dopants. D. Wright et al. (Royal Signals Radar Establishment, UK) have achieved electron diffusion lengths of 2 μ in Zn-doped MOVPE GaAs for image intensifier tube cathodes. J-P. Andre et al. (Laboratoire d'Electronique de Physique, France) have grown AlGaAs at varying temperatures with H_2Se dopant; at 850°C they achieved photoluminescence intensities comparable to those obtained with GaAs LPE. A.T. Vink (Philips, The Netherlands) reported on the growth of AlGaAs epilayers and DH lasers by MOVPE, noting that if water-vapor and oxygen contamination is rigorously reduced, lasers with performance comparable to that associated with LPE can be made. He also explained an ingenious method for measuring the nonradiating part of minority carrier lifetimes. T. Ikoma's group (Univ. of Tokyo) grew GaAs wafers under As to Ga mol fractions from 5-50, using DLTS to determine the energy, cross section, and density of well-known traps, as well as of several "new" ones. L. Samuelson (Univ. of Lund, Sweden) also reported on the characteristics of deep-trapping levels as a function of growth parameters (primarily As to Ga ratio). C.Y. Chang et al. (Cheng Kung Univ. Taiwan) found that better GaAs could be grown by low-pressure MOVPE if triethyl Ga was used instead of trimethyl Ga. The session concluded with a report by G. Laurence et al. (LEP, France) on the suitability of realtime ellipsometry for monitoring heterostructure (AlGaAs-GaAs) growth via MOVPE.

P.D. Dapkus (Rockwell International, US) opened the session on mechanisms and reactants with an invited paper concentrating on the growth of high-purity, undoped GaAs by atmospheric and low-pressure MOVPE. The work reported was done in collaboration with researchers at the University of Illinois. Using trimethyl Ga, repurified by distillation, and identical growth conditions (adjusted for lower pressures), superior GaAs (77K mobility of 110,000 cm^2/V sec) was obtained at 0.1 atm (vs87,000 cm^2/V sec at 1 atm). In addition, there was a dramatically better surface morphology for thick, low-pressure MOVPE films. A. Zaouk et al. (Ecole National Superieure de Chimie, Toulouse, France) outlined the problems encountered in attempting to grow thin III-V films from coordination compounds (Lewis acids for Ga, Lewis bases for As, P, and N). The growth mechanism in GaAs MOVPE was studied by M. Leys (Phillips, The Netherlands), who investigated the diffusion of a GaAs molecule through a flow-boundary layer above the substrate.

In another invited paper, R. Dingle (Bell Labs, US) compared multiquantum-well structures grown by MBE and by MOVPE. Dingle also reviewed the present controversy concerning various mechanisms of radiative recombination in the two structures. E. Veuhoff et al. (Aachen Tech. Univ., FRG) reported on a novel marriage of MBE and MOVPE techniques to allow deposition in an ultrahigh vacuum, thus permitting analytical study of growth mechanisms. The resultant films of unintentionally doped GaAs were p type with $n_h = 10^{16}/cm^3$ and room-temperature mobilities of around 100 cm^2/V sec. J.J. Coleman et al. (Rockwell International, US) described their ultrathin multiquantum-well heterostructures in GaAlAs-GaAs, and reported Se-doped room-temperature mobilities of over 6000 cm^2/V sec.

There were 10 presentations on MOVPE fabricated devices and device structures. In his invited paper, M. Bonnet (Thomson CSF, France) discussed Thomson's production of low-noise FETs grown by low-pressure MOVPE. Noise figures of 3.5 db and gain of 7.5 db at 10 GHz were achieved for GaAs on undoped semi-insulating substrates. Another invited paper by T. Nakanisi et al. (Toshiba, Japan) proved to be of much interest to the industrial attendees, as he reported obtaining a maximum GaAs LN_2 temperature mobility of 139,000 cm^2/V sec, and MESFETs with 1.8 db noise figures and 8.5 db associated gain at 18 GHz. S. Hersee's group (Thomson CSF, France) discussed their success in "gettering" oxygen in a buffer layer in GaAlAs heterostructure lasers. P. Balk (Aachen Tech. Univ., FRG) reviewed his laboratory's extensive MOVPE device work which extends to microwave transistors, LEDs, and lasers of GaAs and GaP. Also mentioned were "an integrated wavelength converter and a light amplifier." A second invited paper from Bell Labs, by R. DuPuis, described excellent double-heterostructure lasers by GaAlAs-GaAs MOVPE. R. Bradley (Plessy, UK) reported good success in producing optoelectronic GaAlAs-GaAs devices; his group found that p-type doping with di-ethyl zinc was more reproducible. R. Azoulay et al. (Centre National d'Etudes des Telecommunications, France) also reported work on E-O devices, particularly integrated injection lasers with grown mirrors. Another CNET group, discussed by D. Ankri et al., has been growing complex multilayer heterojunction structures for microwave, logic, and photodetection devices by MOVPE. Andre and his associates (LEP, France) are producing photocathodes for image intensifier tubes and, through an "inverted structure" GaAlAs-GaAs double heterostructure, they have obtained electron diffusion lengths of 5 to 7 microns. R.R. Saxena (Varian, US) discussed MOVPE GaAs growth processes. His explanation was given in terms of a diffusion-controlled, mass-transport-limited, growth mechanism. GaAlAs solar cells were achieved with performance comparable to LPE devices.

A session was devoted to other III-V compounds by MOVPE. J.P. Hirtz et al. (Thomson CSF, France) grew GaInAs and GaInAsP DH lasers emitting at 1.27 μm, with a J_{th} of 1.5KA cm^2. A novel solution to the problems of thermal instability of indium alkyls in MOVPE was described by R.S. Moss and J.S. Evans (British Telecom Res. Labs). By reacting the In-alkyls with a Lewis base before decomposition in the presence of group V hydrides, device-quality InP and GaInP resulted from atmospheric pressure MOVPE. J. Yoshino et al. (Tokyo Inst. of Technology) are concentrating on low-pressure MOVPE of GaInP and have thoroughly studied the effects of variations in reactant flow rates and substrate temperatures. As in the Varian work, materials comparable to those produced by LPE have been achieved.

An evening "Rump Session" was devoted to the purity of source materials, safety, growth mechanisms, and future directions of MOVPE. The first subject, which involved preventing impurities in the starting chemicals, could easily have taken up the whole session. There was general agreement that the problem was serious, but no conclusive approach to a solution emerged. Safety was generally agreed to be a problem, but a soluble one, within current standards for hazardous materials. Although an attempt was made to discuss all possible reaction mechanisms, attention kept returning to the idea of diffusion to, and decomposition on, the substrate surface. No conclusion was reached, although it was felt that a simple set of suitable low-temperature experiments should provide considerable insight. As expected, the general feeling was that MOVPE had a bright future.

Continuing the session on other III-V's, H. Beneking and H. Roehle (Aachen Tech. Univ., FRG) talked about their experiments on the luminescence of MOVPE GaP and GaAlP. Nitrogen doping, using NH_3, resulted in optically active nitrogen centers. The MOVPE of AlSb photovoltaic devices is the goal of A. Tromson-Carli et al. (Centre National de la Recherche Scientifique, France). To reduce the formation of Al_4C_3 and prevent other problems, tri-isobutyl aluminum was used instead of tri-methyl aluminum; this allowed deposition at lower temperatures. G. Nataf and C. Verie (also of CNRS) are growing InAsSb on InAs and InAsSb on Al_2O_3 for IR photodetectors.

The final session was devoted to II-IV and other compounds. Two papers by J.B. Mullin and S.J.C. Irvine (RSRE, UK) opened the session on an optimistic note, with Mullin's review indicating the attractiveness of MOVPE for II-IV. Irvine followed with a detailed description of growth and characterization of MOVPE HgTe and CdTe. Lower growth temperatures (400-450°C) allow better control of the process, and good surface and electrical characteristics are being obtained. J.E. Andrews (Research Triangle Inst., US)

is growing $ZnSiAs_2$ for photovoltaic devices. A 2 μ buffer layer of silicon, grown on the silicon substrate at 900°C, produced good material from subsequent MOVPE in a proprietary reactor design. The final paper, by H.L. Hwang (Industrial Technology Research Institute, Taiwan) described that organization's efforts to grow $CuInS_2$ on GaP for photovoltaic devices.

Two short presentations by representatives of reactor manufacturers were added to the program. R.G. Clew (GEC Hirst, UK) briefly described an automatically controlled, 8-cm-diameter, vertical reactor with wafer rotation and rapid loading/unloading. G. Crawley (Cambridge Instruments, UK) described a "double bell jar" reactor, capable of producing 20 three-inch wafers. One of these has been delivered to Thomson CSF to be used for developing processing techniques.

In general, the participants were excited about the MOVPE technique. Purity was acknowledged to be a universal problem, but it was anticipated that, as commercial demand grew, the materials suppliers would respond to that demand and would provide products that conformed to the standards of purity required.

The full proceedings of the conference will be published in *The Journal of Crystal Growth* by late summer 1981. The next MOVPE conference is to be organized by J.B. Mullin of RSRE.
(John W. Bailey, US Air Force European Office of Aerospace Research and Development)

A VISIT TO ISRAEL - PART II - TEL AVIV UNIVERSITY

This report describes my visit to the relatively new Tel Aviv University which is located in Ramat-Aviv, a northern suburb of Tel Aviv. My discussions were almost exclusively with persons who were engaged in some aspect of research on condensed matter. Electrooptics research at this university were described in a previous article (*ESN* 33-11: 481 [1979]).

Phase Equilibria

On the day of the visit, Prof. A. Voronel was away from the University performing his compulsory military service at a nearby base. However, he was able to secure leave to return to the university to discuss his work. Voronel is a Russian immigrant who came to Israel from Moscow in 1975 where he had been section head at the Scientific Research Institute for Physicotechnical and Radio Engineering Measurements. Although he had worked at that institute for 18 years, Voronel lost his job shortly after he applied for a visa. He continued scientific work at the "seminar" in Moscow (he was one of the founders) and managed to survive by performing manual labor and with the help of royalties from his wife's writings. The wait for a visa took 3 years.

Voronel has long been interested in thermal properties and critical phenomena in liquids, and he is credited by M.W. Zemansky in his book, *Heat and Thermodynamics*, with the first measurements (1963) of the specific heat at constant volume versus temperature (C_V vs T) at the critical volume, and through the critical isotherm. A summary of Voronel's work in Russia on both pure liquids and solutions is contained in a chapter of the book *Phase Transitions* 5B, 343 (Editors M. Green & C. Domb, Acad. Press, London [1976]).

Since coming to Israel, Voronel has continued this type of work. Using an adiabatic calorimeter with a temperature drift rate of between 10^{-2} and 10^{-3} K/h, he and his co-workers have found that the heat capacity, C_p, of pure alkali metals and alloys increases as the liquid is cooled toward the freezing point. The heat capacity was found to be a universal function of the reduced temperature T/T_c, where T_c is the critical temperature ($T_c \sim 2000 - 2500$ K for the alkali metals). In the stoichiometric alloy KCs, this prefreezing anomaly was thought to be associated with ordering in the liquid state (*Phys. Lett.* 79A 183 [1980]).

Further calorimetric and electrical resistivity experiments on the solid alloy KCs showed the presence, below 185 K, of a new ordered intermetallic compound thought to be K_2Cs (*Journ. Phys. Chem. Solids* 42 23 [1981]). X-ray diffraction measurements of azeotropic KCs (at the 50-50 composition, there is no separation between liquidus and solidus) confirmed this conjecture. Between 233 K (just below the melting temperature) and 180 K, the diffraction pattern does not contain any powder lines arising from crystallites but only a diffuse background which is consistent with a randomly distributed solid solution. Below 180 K, phase separation occurs and an ordered phase with a powder pattern characteristic of a hexagonal lattice appears. Below 120 K the X-ray diffraction pattern is still characteristic of hexagonal symmetry but exhibits changes in the lattice parameters corresponding to an enormous shrinkage of the atomic volume of approximately 14% (*Journ. Phys. Chem. Solids* 42 19 [1981]).

Additional electrical resistivity measurements on the transition at 120 K show it to be essentially independent of composition and also show that the resistivity is maximum at approximately 33 at.% Cs. These results, along with the x-ray and calorimetric data are evidence for the existence of the stoichemetric compound K_2Cs. The low Debye temperature and large volume change at the transition near 120 K are ascribed to the rearrangement of the electronic structure of Cs (*J. Phys. F: Metal Phys.* 10 L 261 [1980]).

Similar work is being conducted on mixtures of Na-NH_3, which, Voronel said, is a material that possibly can be used in a thermodynamic cycle at temperatures near the room ambient. He and his co-workers have recently reported on the heat capacity of three different compositions of the mixture in the 200-300 K range (*Phys. Rev. Lett.* 45 1338 [1980]) in which they showed evidence for a new two-phase region above the critical point. It is believed that, at equilibrium, this region is composed of a metallic phase and an insulating phase with different concentrations of electrons. Voronel plans to extend the heat capacity measurements on the Na-NH_3 mixture over a wider range of the phase diagram and to perform electrical resistivity measurements on these same compositions.

Ultrasonics

The velocity of acoustic waves in a solid is dependent on the state of strain and therefore the stress to which it is related through the elastic constants. Both longitudinal and shear waves have been used to measure uniform bulk stresses in solids. Similarly, Dr. K. Jassby of the Materials Laboratory is using surface acoustic waves to study surface stresses. Analysis shows that the fractional change in the acoustic transit time can be written as a linear combination of the two orthogonal surface stresses σ_{11} and σ_{22}:

$$\frac{\Delta t_1}{t} = K_1\sigma_{11} + K_2\sigma_{22}$$

$$\frac{\Delta t_2}{t_2} = K_2\sigma_{11} + K_1\sigma_{22}$$

where t_1 and t_2 are the transit times in the directions of σ_{11} and σ_{22}, respectively. In principle, the coefficients K_1 and K_2 can be calculated from the measured values of the second and third order elastic constants, but this procedure is undesirable because of the accumulation of errors. Jassby has chosen to determine the coefficients experimentally by the imposition of a uniaxial stress state which is applied by stressing a rectangular cross-section specimen in a tensile test machine. Each material to be studied must be calibrated separately.

Waves can be generated in the surface by coupling through a plastic wedge coupler at the critical angle or by driving a hard (steel) wedge normally into the surface. Both methods have disadvantages: the plastic wedge coupler and its attendant coupling fluid are very sensitive to changes in temperature and the signal using the driven wedge technique is quite small.

Jassby has constructed and applied for a patent on a new surface-wave device which utilizes both techniques: a plastic coupling wedge for generating surface waves and two hardened steel wedges normal to the surface for detecting them. The surface wave in the test material generates a bulk wave in each of the steel wedges which is detected by a standard piezoelectric transducer. The two steel wedges are cast rigidly in an epoxy-tungsten matrix so that their spacing is fixed. The time required for the surface waves to travel that distance is the time between the signals received by the steel wedges. The device is easy to use by clamping in place and is capable of high reproducibility. An accuracy of measurement of approximately 0.02% is claimed. Using this device, Jassby has measured biaxial surface stresses in several aluminum alloys.

Prof. David Gerlich is continuing his work on elastic constants - both second and third order. Originally from Israel, Gerlich spent considerable time in the US at RCA, where he published many papers on the measurement of elastic constants. Now returned to Israel, he is building up a laboratory. He has acquired an ultrasonic generator and associated equipment and has almost finished the construction of a hydrostatic pressure apparatus for velocity measurements up to at least 40 kbar. Using the pulse superposition method and phase-sensitive detection, he can attain sensitivity of a few parts in 10^7. Gerlich will begin this work soon with measurements on BaF_2 and CaF_2, and he expects to evaluate the first and second derivatives of the modulus versus pressure curve as he has done in other work (*Journ. Phys. Chem. Solids* 39 1189 [1978]). In future work he wishes to emphasize the geophysical applications, and he has a long-term goal of obtaining the equation of state for the earth's mantle.

Solid State Theory

The problem of determining the effective bulk dielectric constant of a mixture of two different materials is an old one, and one which was considered by both Maxwell and Lord Rayleigh. Recently, interest has been revived as a result of the possibility of constructing composite material devices. The Rayleigh problem of a simple cubic array of dielectric spheres embedded in a different dielectric medium has been solved, using computers, by calculating the polarization of the spheres in terms of a multipole expansion of up to 100 terms.

At Tel Aviv University, Prof. D.J. Bergman has taken a different approach in which the electrostatic potential in the composite dielectric is set up as a functional equation with a linear operator. The problem is then similar to that of calculating single-electron states of a group of interacting atoms and, in addition, as a result of the periodicity, Bloch's theorem can be used to simplify the calculations (*J. Phys. C: Solid State Phys.* 12 4949 [1979]). Bergman and D. Stroud (Ohio State Univ.) have extended this type of calculation to problems of scattering (*Phys. Rev.* B22, 3527 [1980]), and Bergman has also developed rigorous bounds for the complex dielectric constant of a composite material. A short note appeared recently (*Phys. Rev. Lett.* 44 1285 [1980]), and a more complete account has been submitted for publication in *Journal of Physics C*. Bergman emphasized that in his method the geometrical and physical properties of the problem are well separated and the method is not limited to dielectric properties: permeability or elastic constants could also be treated similarly.

Semiconductor Lasers

Prof. A. Katzir, the leader of an applied physics group of about 15 people, mostly students, has been at the university for three years. Previously he had spent 3 years with A. Yariv at the California Institute of Technology. The group has been working on solid-state lead salt lasers which have emissions in the 6-to-30 μm region. PbSnTe has an emission at 10 μm at 77 K which can be varied between 8 and 12 μm by changing the temperature. Katzer's group grows a double heterostructure of PbSnTe surrounded by PbTe (which has a lower index of refraction) by liquid-phase epitaxy. Lasers made from this material can be operated at CW between 4.2 and ~ 120 K with an output power of approximately 1 mw. At a wavelength of 10 μm, the linewidth is approximately 3 MHz which, according to Katzir, is fairly narrow for a semiconductor laser.

Several applications for these lasers were mentioned. (1) Their linewidth is sufficiently narrow so that they are suitable for high-resolution IR spectroscopy and environmental monitoring. Katzir thinks that parts per trillion of air contaminants can be detected. (2) Lead-salt lasers could be used for long-path fiber-optic communications. In certain fibers (such as AgCl) the optical attenuation as a result of the competing processes of Rayleigh scattering and phonon interactions is expected to have a minimum in the 6-8 μm range with an associated attenuation constant of perhaps 10^{-5}db/km. (3) Since these lasers have a low thermal conductivity and a fairly strong dependence of wavelength on operating temperature, they can be used as heterodyne detectors which sweep through a wavelength band in one pulse. (During a pulse the laser material heats up and changes the operating wave length.) Katzir plans to use this effect in IR astronomy. The work is to be carried out at a site 50 miles south of Beersheba where the climate is very dry and consequently there is very little atmospheric absorption from water. (John R. Neighbours)

THE FRAUNHOFER INSTITUTE FOR APPLIED SOLID STATE PHYSICS

The Fraunhofer Gesellschaft (FhG) was established in 1949 as a society for the advancement of applied research. The Institut für Angewandte Festkörperphysik (IAF) in Freiburg-im-Breisgau, FRG, one of 23 FhG scientific institutes, is composed of six departments in which work is being carried out on solid state physics and chemistry; infrared, microwave, and display physics; and process technology. My visit was prompted by IAF's research on optical coatings and materials, in particular some work by Dr. A. Bubenzer. Bubenzer was away from the institute when I visited, so Dr. Peter Koidl, head of the Solid-State Chemistry Department, served as my host.

His department is really in the business of materials science, with three application areas: passive infrared (IR) materials, electrooptical and nonlinear optical crystals, and laser materials. The majority of the work in IR materials is on ZnSe for windows; they are also interested in materials for multilayer dielectric coatings and amorphous carbon coatings. However, the growth of optical coatings at IAF is only just beginning. IAF has a

thermal/electron-beam evaporative system, and will use an rf plasma-activated deposition for the carbon films. Electro-optical and nonlinear optical research activities are directed primarily to three materials: $LiNbO_3$ for holographic storage and parametric oscillators; $AgGaS_2$ as an IR mixer; and $InPS_4$, which is grown at the University of Freiburg and characterized at IAF. $AgGaS_2$ is a candidate for use in a parametric system to convert 10.6 micron radiation to visible wavelengths. IAF has performed such a conversion to .57 microns with 60% quantum efficiency using a suitable "pump" source. They are growing the crystals in double ampules by the Bridgman technique (double ampules because the material expands on cooling). Crystals 10 centimeters long have been grown; domains and twinning limit the size. After annealing and orientation the typical size is only 2 cm.

Laser materials are being developed to replace the YAG in Nd:YAG. The replacement host material presently under study is $YAlO_3$. $YAlO_3$:Nd (for operation at 1.08 μ) has been grown by Kristalloptik Laserbau, a manufacturer of laser systems and materials in Furstenfeldbruck, FRG, and is being characterized at IAF. $YAlO_3$:Er is also to be investigated for "eye-safe" application (operating at 1.66 μ). Studies on these materials include growth optimization, co-doping, and orientation of the crystals.

Of more direct interest to the optical coating area are the department's characterization facilities. Transmission and reflection can be measured between liquid nitrogen temperature and room temperature. IAF also has a CO_2 laser calorimeter which can map a component or thin film with a resolution of 50 microns. Thin-film structure and impurities are studied using scanning electron microscopy, X-ray fluorescence, X-ray diffraction, and secondary ion mass spectrometry. IAF is working with Prof. G. Busse at the Hochschule der Bundeswehr in Munich on depth-resolved photoacoustic spectroscopy. They have also implemented a coupled-mode method (as opposed to the usual matrix method) for their software which calculates the physical location of absorption centers.

The infrared physics group, headed by Dr. J. Baars, works on detector technology, especially HgCdTe and Si devices. IAF had been studying vapor-phase epitaxy of PbSnTe, but has now transferred the results to industry. HgCdTe is provided to IAF by electronic firms for characterization by several techniques, including reflection and absorption of films near the band edge, Hall effect measurements, homogeneity testing (using a 50 micron-spot laser to produce electron-hole pairs), and surface analysis. The group is studying native oxides on HgCdTe as passivating layers and insulators for MIS structures. The constitution of the layers is still unknown; sputtering, X-ray excited photoluminescent spectroscopy, low-energy electron diffraction, and residual gas analysis are being used to try to determine the nature of the oxide. The most probable structure is a combination of cadmium and tellurium oxides in a heterogeneous mixture (including both mono- and bi-tellurides). The oxides are grown both in-house and by AEG Telefunken's facility in Heilbron. Other research includes extrinsic silicon detectors for the 3-5 micron region, an investigation of indium as a dopant, and electrical characterization of detectors using breakdown measurements and studies of coupling between photoconductors and charge-coupled devices.

The microwave physics group, with Dr. W. Haydl as its head, is preparing III-V semiconductor devices for 90-through-140 GHz operation. InP mixers and Schottky diodes, and molecular-beam epitaxy GaAs Gunn diodes are produced in-house. The group is also studying Si buffer layers in SnTe devices as a means of producing very abrupt junctions.

The technology group is working on device processing development. Research topics include: plasma etching (with 15:1 selectivity between SiO_2 and Si); plasma deposition of Si; and ion implantation. The group has two ion accelerators, one of which is being used for studying implantation of a large number of materials, and the other for research on simultaneous ion implantation and molecular-beam epitaxy. Super-channeling is also being studied. Dr. C. Fritzsche, the head of the technology group, is currently investigating implantation damage using a scanning electron microscope (SEM) and observing the interference caused by backscattered electrons. Fritzsche is using wafers of which only one-half has been ion implanted. The interference which is observed is related to the difference in the absorbed current in the two halves. The presence of damage from the implantation destroys the interference effects. This technique measures the amount (but not the type) of damage left by implantation and subsequent annealing. He hopes to learn enough from these investigations to optimize the implantation and annealing parameters. The SEM also provides two-dimensional information about the boundary between

the implanted and non-implanted regions. An interesting result of this work has been produced by simultaneously measuring the X-ray output using a microprobe. Fritzsche has found that the damage boundary is physically displaced from the implantation boundary by as much as four microns (as a function of implanted mass). Since the technique looks at near-surface damage only, something fairly unusual is taking place. The displacement of the boundaries is also a strong function of the crystallographic orientation of the boundary.

Prof. J. Schneider is the head of the solid-state physics group. His group is studying many of the materials produced by the solid state chemistry laboratory. It is also investigating magnetooptical effects and magnetoelastic interactions. Point defects in Si and III-V compounds are characterized using electron spin resonance and optical spectroscopy. Other research includes Brillouin scattering by spin waves, optical absorption by small polarons, and the use of double-donors (e.g., Si:Te) to produce shallow levels of approximately 199 meV for devices operating in the 8- to 13-micron range. Brillouin scattering has been measured using a double Fabry-Perot interferometer which has a free spectral range up to 100 wave numbers.

To summarize, the IAF is performing a variety of research, much of which complements electronic and optical programs in the US DOD laboratories. Good informal contacts already exist between the institute and some of these laboratories, and a better interaction would be of benefit to both groups. The characterization equipment for optical thin-film coatings is of high quality, and the personnel are well matched to the facilities. While the production of coatings is only just beginning, IAF should be a group to watch in the future. (Armen E. Mardiguian, US Air Force European Office of Aerospace Research and Development)

NEWS AND NOTES

NEW SLOW NEUTRON DETECTOR SYSTEM AT UK RUTHERFORD AND APPLETON LABORATORIES

A research and development program on new techniques and devices for use in neutron scattering experiments has been continuing for a number of years at the UK Science Research Council's Rutherford and Appleton Laboratories (RAL). One line of development which is now bearing fruit is a new type of "position sensitive" slow neutron detector system (PSD). It has been recognized for a long time that many neutron-scattering experiments would benefit greatly by the use of a detector of large area capable of recording electronically the coordinates of each neutron detected. Such a PSD can be equivalent to many thousands of individual detectors (and indeed is sometimes known as a multidetector) and makes much more efficient use of expensive neutron beams which are comparatively weak even at high flux neutron sources. The RAL work has concentrated on the use of the scintillator technique, since this is considered to be the best solution for detectors required by the new generation of high-intensity pulsed neutron sources such as the Spallation Neutron Source (SNS). Instruments at these sources use the time-of-flight technique of neutron scattering exclusively so that one important requirement of a detector is thinness ($\lesssim$1 cm thick) to avoid uncertainties in the flight path. Another is short dead time ($\sim$100 ns) so that high count rate during the short bursts of neutrons can be achieved. A third requirement is adequate detection efficiency over a wide range of neutron energies extending well into the epithermal range. In addition, as for all slow neutron detectors, the system must adequately reject all the other unwanted radiations which always accompany the production of neutron beams, for example, fast neutrons and gamma radiation.

In the new system, neutron-sensitive scintillators are optically coupled to a bank of photomultipliers in an unusual way. The neutron-sensitive area is a mosaic of separate resolution elements, each one coupled by three flexible, coated plastic fibers to a unique combination of three photomultipliers out of a bank of N. Thus by detecting which three photomultipliers have "fired," the resolution element in which the neutron absorption occurred can be identified. The number of resolution elements (which can be any shape on a plane, cylindrical or spherical surface) which can be encoded in this way by N photomultipliers is giving by permutating 3 out of N; for example, 30 photomultipliers are enough for over 4,000 resolution elements. By using a scintillator in the form of sheets of cerium-activated silicate glass loaded with an isotope of lithium to absorb the neutrons, the detector specification outlined above can be met.

A prototype system using lithium-loaded zinc sulphide as a scintillator, was successfully used in a neutron-scattering experiment on the D7 instrument at ILL (the Institut Laue Langevin at Grenoble, France) in 1980. Economical methods of manufacturing the fiber-optic encoders have now been developed. It is expected that these systems will provide reliable, portable detectors with good efficiency and count-rate capability at moderate cost, thus enabling the advantages of PSDs or multidetectors to be much more widely available to neutron scattering scientists than hitherto.

UK MOD APPROVES MARCONI M1600 AS AVIONIC VERSION OF ARGUS M700

The UK Ministry of Defence (MOD) has approved the Marconi MC-1600 military computer for military avionics. This machine uses the Ferranti M700 architecture in accordance with the MOD computer standardization policy described elsewhere in this issue.

Though mechanical incompatibilities and avionic power needs may preclude complete interchangeability of the two computers, the approval is another indication of the UK determination to settle on a standard architecture for its MOD computer policy.

TRANSMISSION OF UNDERWATER IMAGES BY ACOUSTIC WAVES

According to a recent announcement, in February the Societe Thomson-CSF (Paris, France) demonstrated the continuous transmission, with acoustic waves, of TV images that were being filmed at a depth of 1,000 meters. The demonstration was held on Castillon Lake in the southern range of the French Alps.

According to Thomson, the technique will have applications in many fields, particularly the oil industry, to monitor underwater structures by means of remote controlled vehicles or manned submarines.

Thomson claimed that its system can cope with a much higher data rate than previous systems.

The acoustic transmission technique used is similar to that used in space exploration systems. The signals from the camera below are decoded and stored to allow display on a TV screen with a continuous sequence of still images. A directive acoustic receiver is used to reduce noise and reverberation.

Along with high-capacity transmission, the system also provides for transmitting remote-control signals to the underwater station.

Possible future applications include the transmission of images and other data, such a telemetry information, between a submerged craft and several surface ships, between surface ships and submarines, or between submarines and submerged equipment.

TAILORING JOBS AND EQUIPMENT TO PEOPLE

Human factors specialists often observe that the "people aspects" of a new hardware item are ignored until the design has been frozen; after that, only minor changes in display and control features may be practicable, and so a system may be fielded which is unsatisfactory to the people using it. Enough information is available now to predict and prevent some of the worst cases. As one example, scientists at the British Army Personnel Research Establishment at Farnborough were able to show, with a prototype, that an advanced new armored vehicle could be operated by only about 5 percent of the men in the Army.

There are several projects at Farnborough which monitor continuously the effects of noise, effort, and stress on the worker's body. Sensors indicate the energy expended in muscular movements and the variations in heart rate. Tiny cassette recorders obtain the data; a pool of regular soldiers has been assigned to serve a human for two years—that assignment itself shows the commitment of the Army to the work. Most of the information from research trials should be useful to industry as well, since the problems associated with lifting, loading, and controlling are remarkably similar in the military and civilian circumstances.

BACKING FOR EUROPEAN RESEARCH FUND

A European Research Fund which would launch new projects and coordinate work by scientists throughout Europe has been backed by a Council of Europe conference. More than 200 delegates at the council's fifth parliamentary and scientific conference in Helsinki last month urged that a fund to boost vital fundamental research in Europe be established, and they also called for "a more meaningful dialogue" between politicians and the European Science Foundation.

Lord Flowers, rector of the UK Imperial College of Science and Technology, believed the projected research fund could provide a mechanism enabling European scientists to communicate through official bodies. However, he warned that governments could be reluctant to back the scheme: "They might say they have already provided the money that science deserves. What the fund would need would be encouragement money. And I hope at least modest sums to launch joint European activity will be forthcoming."

In its final communique, the conference took some of the sting out of the fund proposal. It said that recommendations and any amendents would be examined by the Council of Europe's parliamentary commission on scientific and technological questions before submission to the plenary assembly. According to some observers, such a cumbersome procedure may be offset by a newfound desire to pool the efforts of the Council of Europe, the EEC and the OECD, the overwhelming support for a comprehensive approach to research problems, and the key role accorded to the European Science Foundation.

SRC CHANGES NAME

The UK Science Research Council recently decided to change its name to the Science and Engineering Research Council. This change was approved by Queen Elizabeth II in Council on 13 April 1981.

DIRECTOR APPOINTED FOR TECHNICAL CHANGE CENTER

Prof. Sir Bruce Williams, Vice Chancellor of the University of Sydney, Australia, has been appointed director of the UK Technical Change Center.

The Technical Change Center was set up in late 1980 with the support of the SRC, the Leverhulme Trust and the Social Science Research Council. The function of the center is to develop a major program of research on the choice, management and acceptability of technical change relevant to the advancement of the national economy.

The center is governed by a board with an independant chairman, members from the three main sponsors, from both sides of industry, from government and the academic community.

The center will produce analyses and suggest policies which will be independent of, but complementary to, those generated by government, industry, and other interest groups. The program of work will deal with a range of policy issues, but particular emphasis will be placed on resource use, technological change, and scientific development. A continuing theme will be the way in which obstacles to the creation and sensible use of wealth can be removed. Types of issues addressed will include: the optimization of energy and materials use and conservation; the problems associated with the expansion of the country's manufacturing base; the extent to which substantial domestic capacity in certain base industries should be maintained; and how technological innovation can be introduced without major social occupational disruption.

ONR COSPONSORED CONFERENCES

9th International Conference on Operational Research, Hamburg, FRG, 20-24 July 1981.

International Symposium on Advances in Polymer Characterization, Durham, UK, 13-17 July 1981.

International Symposium on Hydrodynamics in Ocean Engineering, Trondheim, Norway, 24-28 August 1981.

Conference on Combinatorial Optimization, Stirling, UK, 24-28 August 1981.

4th International Symposium on the Chemistry of Novel Aromatic Compounds (ISNA 4) Jerusalem, Israel, 30 August-4 September 1981.

NATO Advanced Study Institute on "Static and Dynamic Properties of the Polymeric Solid State," Glasgow, UK, 6-18 September 1981.

Fifth National Quantum Electronics Meeting, Hull, UK, 23-25 Septermber 1981.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Navy Lab./Org. to be Visited
Mr. Brian M. Count	Marchwood Engineering Labs, Southampton, UK	Civil Engr. Lab., NCBC (19-20 Oct. 1981) FLENUMOCEANCEN, NEPRF, NPS(21-23 Oct. 1981)
Mr. Stewart L. Wells	Dept. of Electronic Engineering, Heriot-Watt Univ., Edinburgh, Scotland	NOSC (31 August-4 September 1981) ONR West, Scripps Inst. (8-11 September 1981)

ONRL REPORTS

C-2-81

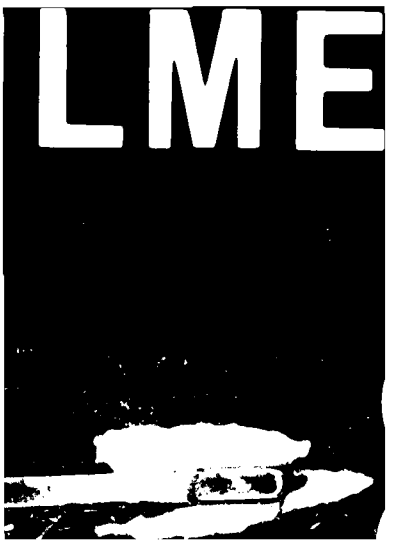
Fifth International Symposium on Air Breathing Engines, by J.R. Patton, Jr.

The Fifth International Symposium on Air Breathing Engines was held in Bangalore, India, in February 1981. The program was primarily directed to the discussion of aircraft turbine engines. This report contains comments on various papers that were of special interest to the author. It also contains the names of all the persons who spoke at the symposium and lists the topics they discussed.

C-3-81

17th International Symposium on Applied Military Psychology, by Nicholas A. Bond, Jr.

The topic of the 17th International Applied Military Psychology Seminar was "Psychological Prediction and Measurement of Individual and Unit Effectiveness." Twenty-two papers and ensuing discussions are summarized under six headings: Selection, Critiques of Selection; Job Satisfaction; Long-term Effects of Stress; Women in the Military; and Projective Testing.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